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Long-Distance Travel Modal Share and Rail Transportation Feasibility in Texas and Louisiana

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Long-Distance Travel Modal Share and Rail Transportation Feasibility in Texas and Louisiana

by

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Report

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Dedication

I would like to thank my chair, Professor Ming Zhang for his support and guidance. It would never happen without his knowledge on transportation demand model, travel survey and socioeconomic database. I also want to thank my co-supervisor, Dr. Junfeng Jiao, for checking in with me and making sure I was on the right track.

It has been a fruitful two-year in Austin. I appreciate all the faculties, colleagues and friends that I have known.

I also dedicate this report to my parents for their remote support so that I can finish my degree without much trouble. My girlfriend, Zhang Xuechun, is my guardian angel when things are tough. Thank you for always being there for me!

Abstract

Long-Distance Travel Modal Share and Rail Transportation Feasibility in Texas and Louisiana

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As US cities continue to accommodate more people and jobs, they have created increasing travel demands, especially on inter-city commute. Due to the spatial distance among cities and a long tradition of car-oriented lifestyle in the south, cars are the major mode for people traveling to different cities. With emerging papers and reports on building a regional framework for the US mega-region, a sustainable transportation network with various transport options has become a heated topic for state and local transportation agencies. Multiple National Household Travel Surveys (NHTS) have shown that private vehicles dominated intra- and inter-megaregion travel in the United States and such travel pattern will cause further congestion on regional highways and negatively impact passenger and commodity flows in mega-region. An efficient mobility supply for megaregions aims to achieve multi-modality that utilize different modes (automobile, rail, bus, and air) for mega-regional travel.

This report utilizes the National Household Travel Survey and ACS commuting flow data to explore the travel patterns of Texans. A mode choice model from National Cooperative Rail Research Program (NCRRP) Report 4 was calibrated to investigate how mode share would change for travelers in the twin-megaregion area that includes the Texas Triangle and western Louisiana. The aggregated findings provide solutions for effective network performance, and the report further discusses the possibilities of modern railway service in the twin megaregion-area. This study starts two case studies where train transit can be effective solutions to transportation supply. Then it explores the traffic corridors in these two states with commuting survey and data. Last, trip generation and mode choice analysis confirm the abundance of rail riders in the future, and the report offers policy suggestions for policymakers to prepare for the potential changes.

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Chapter One: Introduction

With the development of modern transportation, getting to places has become easy for modern-day urban and suburban residents. New implications have been revealed as people can travel long distance easily. The geographical and political boundaries that we defined are not representing of political and economic landscape correctly, and some have become obsolete. The widening of scales of labor activity and sprawl of urban areas present a unique opportunity to examine social matters at the scale of what is knowN as "Megaregion" level. These megaregions are more prominent than typical urban areas and can cross different political boundaries. It connects commodity, people, capitals, and traffics.

The idea of megaregion has been commonly recognized in the states by the start of the 21st century. Lang and Dhavale (2005) identified 10 "Megapolitan Areas" in the United States. They use a series of metrics, including population, geography, and transportation network. It is the first nation-wide study on megaregion delineation. The most influential megaregion study America 2050 by Regional Planning Association (RPA), where it reckons 11 regions as megaregions. (Figure 1-1) The US Department of Transportation (USDOT) also published its version of megaregions to support their promotion of regional railway framework. (Figure 1-2)

In Texas, a well-known definition of megaregion is the Texas Triangle, which is a triangle marked by three anchor cities of Texas, Dallas- Fort Worth, San Antonio, and Houston. Due to the car-dominant lifestyle, there are little modes of transportation other than the car. The capacities of Texas roads and highways have been stretched, and several segments of highways are considered most congested throughout the states. (TTI, 2005) The RPA also includes Louisiana state in the delineation of Gulf Coast. Texas Triangle and Gulf Coast overlap, and the area of two megaregions combined only second to Great Lakes region. This report takes a brand new approach in studying mega-regional traffic patterns and travel demand by combining two megaregions in the analysis.

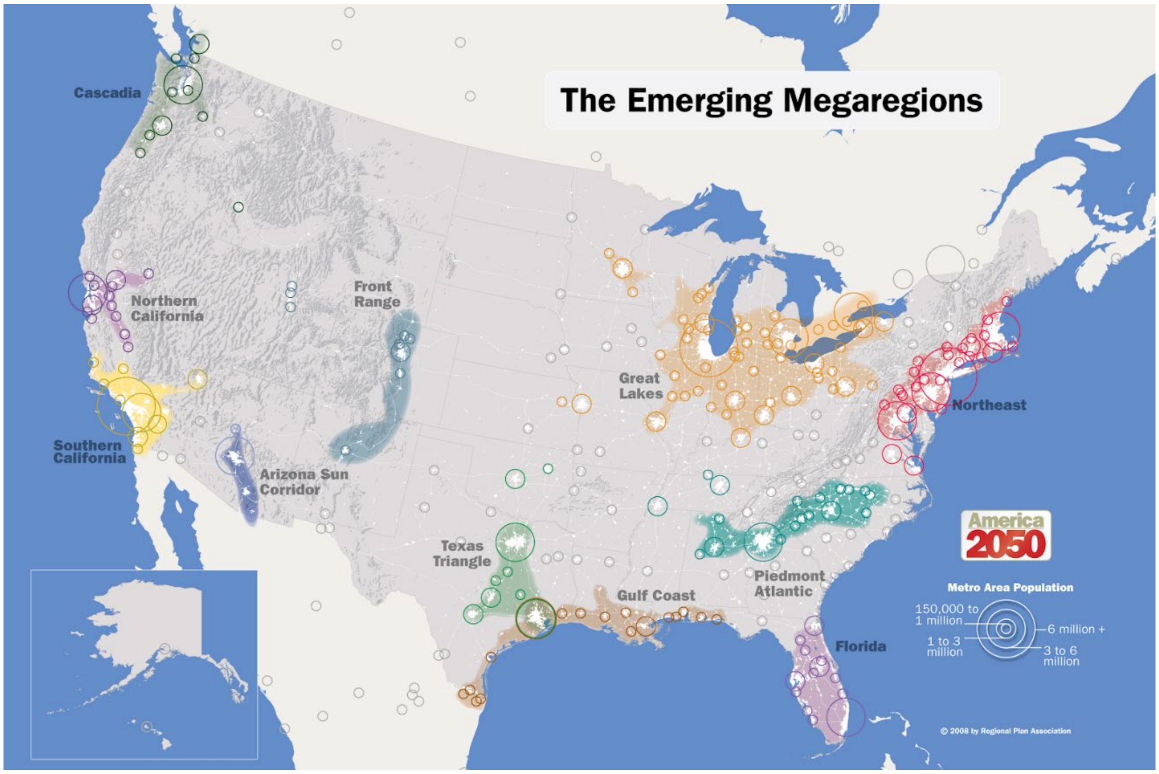


Figure 1-1: RPA's Emerging Megaregions Map

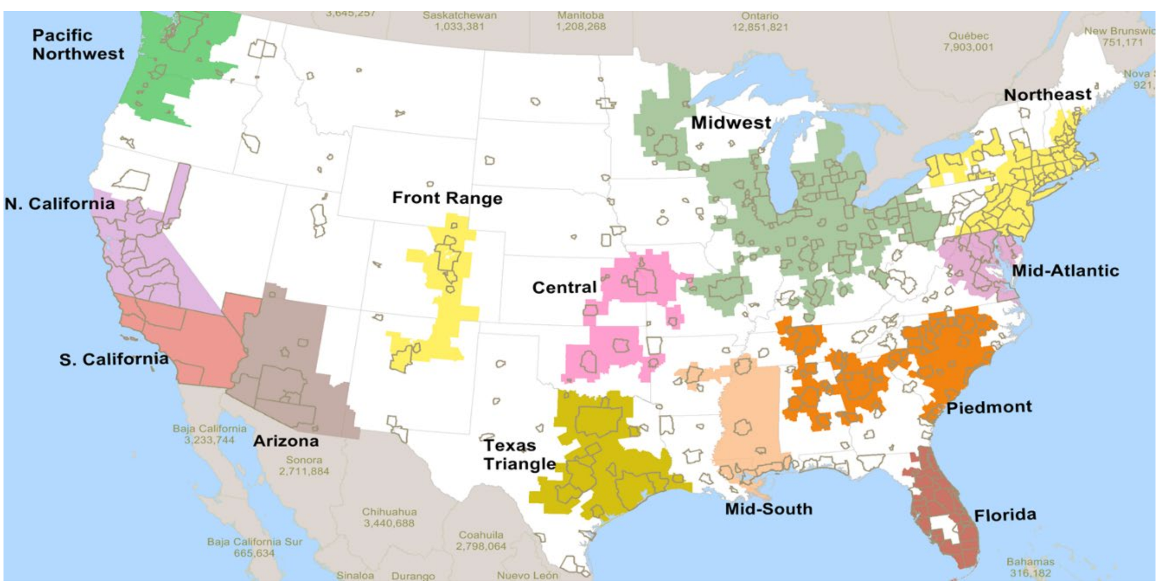


Figure 1-2: USDOT Delineation of Megaregions

According to a report by Texas Transportation Institute (TTI), NHTS 2001 and 2009 data have revealed trends in Texas households and travel. The number of households has been growing by 900 thousand over nine years. Among all households, a one-person household has seen the biggest growth. However, with an increase in households, the household vehicle miles traveled (VMT) decreased by 2 billion.

For personal travel, annual person trips per household grew slightly from 3,493 to 3,598, but average PMT decreased from 38 thousand to 34 thousand. Commute trips and business trips increased for average people. For social and vacations purposes, all have risen except for shopping trips.

In terms of mode share in Texas, the shared commute by car dropped from 97.2% to 94.8%, and that of business also declined from 96% to 92.6%. The mode choice for business travelers remain steady, and they continued to choose to drive without reliable alternatives.

The travel trends in Louisiana is unavailable because Louisiana State does not contract with NHTS to conduct add-on data. Although population growth has been slow for Louisiana, it is expected that it will reach 5 million around 2030 according to API data[1]. Two of the biggest metro areas in Louisiana, New Orleans and Baton Rouge have a population of 1.26 million and 825 thousand respectively.

As both states have seen significant growth in population, it leads to the question of transportation supply and demand. Unprecedented demands for transportation present themselves in the form of increase in car ownership, higher VMT and PMT and more gasoline consumption. On the other end of the spectrum, the states face with stagnated supplies. Texas has kept a leash on building new toll roads and HOV lanes. In terms of performance and maintenance, Louisiana ranked 37th in maintenance disbursement per

[1] Demographic data in Louisiana was gathered from Open Data Network (https://www.opendatanetwork.com/entity/0400000US22/Louisiana/demographics.population.count?year=2017)

mile and Texas comes at 29th. (Fields et al, 2018)[2] These all beg the question: if driving on highway cannot solve the problem, what options we have?

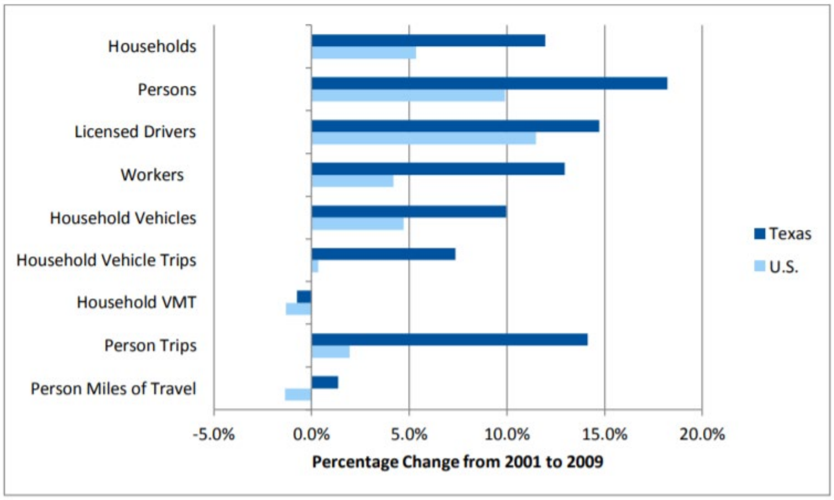


Figure 1-3: Changes in Household and Travel (Source: Bricka, Larsen & Baker, 2012)

Research Objective and Report Outline

The purpose of research resonates with some current trends by investigating the feasibility of introducing new transportation mode to combat current car-oriented lifestyle in the twin-megaregion. The methodology is elevated from traditional four-step modeling where the NCRRP mode choice model is adopted so that that psychological factors can be considered in the research. It also takes into account the commuting flow in Texas and Louisiana, as it takes up a portion of the long-distance trips. Among all transportation modes, HSR has established precedence in multiple countries that it changes the way people take long-distance trips and positively impacts regional development.
Chapter two reviews past literature on long-distance travel and models and database available for the report. Chapter three combines commuter rail studies in the Puget Sound

[2] The 23rd Annual Highway Report. https://reason.org/policy-study/23rd-annual-highway-report/

region and Washington D.C metro area and commuting patterns in Texas and Louisiana. The long-distance commute is an important type of long-distance travel and most regular-service railways in the United States are catered to the needs of daily commuters. The super commuting patterns lead to the heart of the argument that trains are effective to accommodate increasing long-distance travel needs. Chapter Four and Five conduct trip generation and mode choice analysis in twin-megaregion areas by county. They calculate the total trips generated by 2035. The mode choice analysis modifies the US National Cooperative Rail Research Program (NCRRP) Report 4 mode share model to simulate future scenarios in which changes in system performance (e.g., rail operating speed), demographic dynamics, and traveler attitude may result in a more or less balanced modal split in megaregions. The NCRRP model takes demographic data, modal travel time and cost, and attitudinal values as input. A total of six scenarios will be computed, and the chapter will explore their implications for the megaregional transportation system. Chapter six is the concluding chapter and suggests transportation agencies to start actively planning for future needs.

Chapter Two: Long-distance Travel Analysis: Literature Review, Travel Survey and Mode Choice Models

Texas and Louisiana combined have a total population of about 32 million by 2017, taking up 10 percent of the national population. With the large population base, it is no doubt that the region accommodates a large number of trips daily. According to the NHTS 2017 summary file, the daily person trips are 8.6 by each household, and the average daily Person Miles Travelled (PMT) stands at 92 miles. Average person trips increased from 6.36 in 1969 and reached the pinnacle in 1995 at 10.59. Average PMT increased by 30 miles from 1969 to 2017, but there was a downward trend in the 21st century. People are taking fewer trips over the decades, but the distances of trips have been growing.

This chapter takes an inside look into current resources available for long-distance travel. It reviews prior studies on commuting patterns and explains some travel survey and mode choice model in the field that are helpful to the study.

Literature Review

The Federal Highway Administration has led the effort in establishing long-distance passenger demand framework in 2015. This multi-modal framework can simulate annual long-distance business and leisure travel. The model can track disaggregated (individual household) travel behavior year-round. It also integrates mode choice, destination choice and tour generation. (Outwater et al., 2015) The research provides valuable parameters for studying long-distance travel demand. However, it has not reached the implementation phase.

Rich and Mabit (2011) developed a tour-based long-distance travel demand model across 42 countries in the European Commission. The model is based on a nested logit model and distinguishes business, private and holiday trips. Car drivers and passengers have higher elasticities accompanying the increase in travel distances while rail, bus and air riders show the opposite sign. This paper provides another perspective into long-distance travel demand about how travel time and cost would change people's mode in different purpose of travel.

Zhang and Chen (2009) took another approach to understand future travel demand other than the traditional four-step model by incorporating Travel Time Budget and Travel Money Budget. They recognize the mobility demand in the Texas Triangle would continue to grow, and the person travel distance demand would grow by 4 times between 2008 and 2050. As the distance increases and travel time remain relatively steady, travelers are in dire needs of high-speed transport methods. Therefore, they suggest HSR as a future mobility option.

NATIONAL HOUSEHOLD TRAVEL SURVEY AND LONG TRIP FILE

National Household Travel Survey (NHTS) is part of the long-term initiatives of the US Department of Transportation to collect personal travel data and provide policy suggestions for government bodies. The nationwide travel survey was first conducted in 1969, known as the Personal Transportation Survey (NPTS). In 2001, the survey changed its name into NHTS since it integrated with NPTS managed by Federal Highway Administration (FHA) and American Travel Survey (ATS) sponsored by Bureau of Transportation Statistics (BTS). The 2001 NHTS offer a wide array of data regarding characteristics of households, people and vehicles, estimated travel miles, trip purposes and more. (Hu and Reuscher, 2004)

The 2001 NHTS long trips file is an add-on to standard NHTS data. It was the first time long trips were combined with NHTS daily trips. The range of long trips was extended from trips longer than 100 miles to trips longer than 50 miles to capture more trips that were neglected in the 50- to 100-mile range.

MODE CHOICE MODELS

Primarily, mode choice models for MPOs have three major components. Firstly, the primary mode is Auto Modes, and Auto would be nested into several sub-modes: Drive

Alone, Two People and Two or More. Secondly, some larger MPOs would include transits in their model, and transits may be classified by service types, access time, service frequency, and so on. One advantage associated with the intricate classification of transit mode is that these factors have been playing huge roles in people's travel behavior, and it would capture the dynamic in the transport market. However, too many factors about transits would make the model complex and results in more mistakes. Third, the non-motorised mode is an important indicator of the size of the model. In some models, walk or bike trips are considered a part of the transit trip. NCHRP 716 indicates that models for MPOs are rudimentary and rustic. (Table 2-1 and Table 2-2)
It is noted that the parameters are primarily focused on the trip-making process rather than the initiatives or psychological factors. When making mode choice decisions, one would tend to consider their preference for automobile against public transit with a handful of factors. Preference for privacy, environmental thinking and other social behaviors can be crucial in decision making, and yet they are not captured in the MPO models.

TABLE 2-1: MPO TRAVEL DEMAND MODEL GLOSSARY (SOURCE: NCHRP 716)

Model	Population Range	Nested Logit?	Include Nonmotorized?	Auto Submodes	Transit Submodes
A	< 1 million	Yes	No	DA/SR	Local/Premium
B	> 1 million	No	No	DA/SR	None
C	> 1 million	No	No	DA/SR	None
D	> 1 million	No	No	None	None
E	> 1 million	Yes	No	DA/SR	Local/Premium
F	> 1 million	Yes	No	DA/SR	Local/Premium/Rail
G	> 1 million	Yes	No	DA/SR	None
H	> 1 million	Yes	Yes	DA/SR	None
I	> 1 million	Yes	Yes	DA/SR	None

TABLE 2-2: PARAMETERS OF MODE SHARE (SOURCE: NCHRP 716)

Model	In-Vehicle Time	Out-of-Vehicle Time	Walk Time	First Wait Time	Transfer Wait Time	Cost
A	−0.021		−0.054	−0.098[a]	−0.098	−0.0031
B	−0.030	−0.075				−0.0043
C	−0.036	−0.053				−0.0077
D	−0.019		−0.058	−0.081	−0.040	−0.0072
E	−0.025	−0.050				−0.0025
F	−0.044	−0.088				−0.0067
G	−0.028	−0.065				−0.0055
H	−0.033		−0.093	−0.038	−0.038	−0.0021
I	−0.025	−0.050				−0.0050[b]

There has not been a consistent stated preference survey in the Texas region. The 2000 TxDOT Model Manual does not consider mode choice in their model. TxDOT's Statewide Ridership Analysis Report based their mode choice preference from NHTS 2009, which was out-of-date, especially when major MPO's have been making efforts in providing various transit services. In CAMPO model, the nested mode choice model has three general choices(Auto, Transit and Non-motorised) and more branches under the transit category. (CAMPO, 2010)

In CAMPO travel demand model, the mode choice is nested below trip destination, which indicates our attitudes towards auto being the prime mode of transportation. In other words, in a nested model, the upper layer tends to be what people considered first, and by putting the trip destination on top of mode choice plus a scary high share of auto, people inherently choose driving as their trip mode without even considering how they are going to get to the destinations.

Long-Distance Transportation Model

Over the years, there have been increasing trends of inter-city or cross-region trips all over the US. In NHTS 2017, it is indicated that there are over 4000 trips longer than 50 miles collected. Another trend picked up from Census Bureau also suggests that there have been increases in the super-commuting pattern.

Long-distance travel model is different from MPO and other regional models. For urban or regional travel, trips can be divided by whether they start or end at home, but long-distance travel is often categorized by purposes (e.g., business or visiting) or by frequency. There are various factors involved in long-distance mode choice, including travel distance, purposes, travel costs, access and egress time and so on.

Another piece of literature of value on long-distance travel is NCHRP Report 735: Long-Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models. It has taken a comprehensive view of long-distance travel forecasting from trip generation to mode choice. It lists some of the useful data sources for modeling, which includes NHTS and statewide travel surveys. Unfortunately, Texas does not have an aggregated statewide survey system. TxDOT does carry out travel survey every ten years at a regional scale, but the data and reports are not coherent across places. The report synthesizes the parameters from different states' and countries' models, including Georgia, Wisconsin and Canada.

For the trip generation parameters, the researchers have gathered data from ATS and NHTS and tabulated the data by trip purposes and trip distances. On top of that, land use and household statistics were weighted in the calculation of the parameters. Based on the estimation that an average household in the US would make 10.15 long-distance trips. NCHRP 735 is of great value for investigating long-distance travel forecasting. The Texas statewide model is simply a tool for rough estimation rather than an accurate projection for future travels. The parameters cannot serve as universal solutions for every states so that the current report would combine the model parameters with current socio-economic and demographic factors.

MODE CHOICE MODE BY NCRRP 4

The purpose of NCRRP 4 is to explore factors other than travel time and costs in affecting people's travel decisions. Traditional mode choice model would focus on travel time and costs of travel compared to other modes. The study recognizes the effectiveness of traditional factors but also stresses demographic, geographical and psychographic factors could contribute to choosing different travel modes.

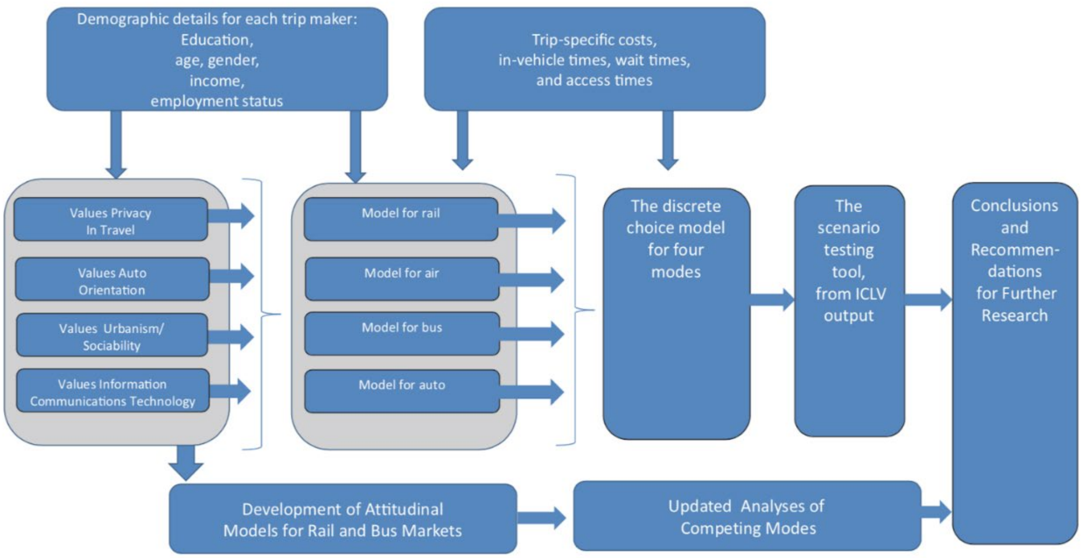


Figure 2-1: NCRRP 4 Model Flow Map

Decreasing Role of Auto Orientation in Future →		*Decreasing Concern for Privacy in Travel in Future →*
Pessimistic for Rail • Bad future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail decreases by 4%***	*Mixed Scenario B* • Good future for auto rejection • Bad future for privacy tolerance • ICT need will decrease with age ***Rail increases by 4%***	
Mixed Scenario A • Bad future for auto rejection • Good future for privacy tolerance • ICT need will continue with age ***Rail increases by 10%***	*Optimistic for Rail* • Good future for auto rejection • Good future for tolerance • ICT need will continue with age ***Rail increases by 18%***	

Figure 2-2: NCRRP 4 Scenarios

From the survey, they distilled the top 10 factors that affect people's choice, and Train Trip Inconvenience is ranked top with double the coefficient than the second factor. The four long-term factors are included in the ranking: the value of auto orientation ranked

2nd, values of privacy ranked 4th, values of ICT ranked 6th, and values of urbanization came at 10th.

They have summarised four possible scenarios for inter-city rail ridership based on the survey responses. Psychological factors towards under 35 cohorts can have a drastic effect on inter-city rail ridership. The study spans a large proportion on the competition between rail and air and rail and bus, so the questions are written towards comparing people's perceived knowledge of different transportation mode. Combining the mode choice model with attitudes and preference can have results that are uncalled for.

Preliminary Analysis of NHTS 2001 Long Trip File

In the long trip file, I filter out those trips that start in Texas, and the total of them come at 2721. Due to the large survey, many survey-takers decided to skip questions about access and egress place, and there are little samples to work with. About 81% of all trips end in Texas, and 4% of them are trips out of the county.

Table A-2 and Table A-7indicate the final MSA destinations that respondents went. There are a total of 2721 households located in Texas. About 81% of the long-distance trips originated within Texas terminated in Texas as well. 866 of all went to a place that is not an MSA or PMSA, so the survey does not include their precise destinations. "XXXX" represents MSAs that have less than 1 million population, and therefore they are suppressed. Dallas, San Antonio, Houston and Austin are top in-state destinations for respondents. For out-of-state destinations, Oklahoma City, New Orleans, New York, Washington DC and Chicago are among the top.

In terms of the mode share of long-distance trips, 88.94% of travelers choose cars as their transport mode, while 8.89% of them used commercial airplanes. The rest 2.9% are buses, cruises and other modes. For in-state travel, the percentage of driving dramatically climb up. The share of cars adds up to 95%, and bus and air take up 3% and 1% respectively.

In Louisiana, about 61% of the trips are travel within the state, and about 13% of them are trips to Texas. (Table A-5) Texas is the second destination state to Louisiana, followed by Mississippi. New Orleans, Houston, Dallas and Mobile are top MSA destinations. About 84% of travelers use cars as their travel tool, and the share of commercial airplanes is about 7%. The average PMT for cars is slightly lower than that of Texas at 161 miles.

Chapter Three: Rails for Emerging Needs: Case Studies and Super-commute in Texas and Louisiana

BACKGROUND

A handful of studies have identified the fact that psychological factors interfere with people's decisions in taking public transit, especially when it comes to choosing bus or train. Rail services tend to leave a better impression on people than bus as people always remember the interior of the trains being bright and clean with comfortable seats and plenty of legroom. Other factors affecting people choosing train over bus include attraction, nostalgia, enjoyment of the ride, and comfort. (Schere and Dziekan, 2012) Railway and train have better reliability, which commuters value. Light rails and commuter trains have dedicated right-of-way, so they are free from congestions and traffic lights. This gives an advantage over car and buses. Also, because of the superiority in the train, it attracts supports from "discretionary riders", who would otherwise choose to drive than taking bus.

Trains, light rails or commuter rails are designed to transport a large number of passengers for longer distance. Compared to bus, train routes have fewer stations, so the station area would benefit from the increase in passenger flows. Bus stations, on the other hand, are difficult to have cluster effects due to its flexibility in station location. Transit-oriented Development(TODs) proves to be more effective around trains stations than bus stations. In Dallas, over $800 million have been invested in commercial and residential properties within walking distance to DART line. Although Dallas did not pass any legislation encouraging TOD development, train destinations are popular for private entities. (Arrington, 2005) In Portland, its transit agency TriMet had funded legally binding station area plans and adopted by the local government before the light rails became operational. The plan was the most aggressive among US TOD programs, and it set standards for minimum densities, parking maximums and so on. According to

Arrington, more than $3 billion worth of new development has happened around the light rail stations, and most of them happened without public subsidies.

Studies also indicate that rail transit system has higher marginal effects in decreasing driving ratio and automobile VMT. A study by Bento et al. (2003, cited in Henry and Litman, 2014) suggests that a 10% increase in rail supply would result in a 4.5% decrease in probability to drive and 40 VMT decline per capita. The mode share of transit is constantly declining across the United States, but Baum-Snow and Kahn (2005) uncover that cities with rail transit system have small percentages of decline than cities without rail transit.

Overall, rail transit has proven effective in converting automobile users into public transit riders than that of buses. Train and rail can successfully attract marginal users (discretionary riders) as train trips are reliable and psychologically superior to most. In terms of mode share, cities pursuing trains can slow down the decline in the share of public transit. Train lines tend to spur intensive development in the surrounding areas and stimulate downtown and suburban center economics. In Texas, commuter rails and inter-city rails are effective measures connecting suburban and downtown and anchor cities as they can offer fast and convenient alternatives to destinations and circumvent congested highways.

The Federal Highway Act of 1956 authorized the construction of 41,000 miles of interstate highway across the nation, and IH-10, IH-35 and IH-45 were constructed within the Triangle. In 2012, SH 130 was open from Buda to Georgetown to divert truck traffic from I-35. TxDOT signed a 50-year Facility Concession Agreement with SH 130 Concession Company, and the $1.35 billion toll highway was built and financed by SH 130 Company. However, the traffic on SH 130 was not as good as expected, and Austin has not seen any sign of getting less congested. Later on, the company filed for bankruptcy protection, and $430 million federally-backed Transportation Infrastructure Finance and Innovation Act loan from the taxpayers were given to the private entities. By 2014, TxDOT was responsible for 197,100 lane-miles of highway and had a biennial budget of $8.6 billion among which 40% of it was dedicated to highway system maintenance. (TxDOT, 2014)

Historically, proposals about high-speed railway construction across Texas have failed or canceled. Texas TGV proposed HSR line along IH-35, IH-45 and IH-10. The Texas High-Speed Rail Authority awarded a fifty-year rail franchise to the Texas TGV Corporation in 1991. TGV had to secure funding from private sources because Texas did not allow the use of state money, and it managed to get funding for an environmental impact study. Eventually, the project failed because the amount of money involved is huge, and the state canceled the project. The Trans-Texas Corridor (TTC) was a proposal to build a gigantic corridor within the Triangle. The project was controversial at its start. It planned to build a 4,000-mile network of highway, rail tracts and utility lines, which requires 1,200 feet of right-of-way. It has received strong opposition from residents along the line, and the project was halted. There are several regional rail studies on Dallas-Oklahoma, Austin- San Antonio and Houston Dallas, they remain at preliminary study or proposal phase. Texas Central Partners, which claim to build the HSR between Dallas and Houston are moving their project forward on land acquisition and environmental impact study.

Local transit agencies have made efforts in providing commuter rails for residents. In Austin, Capital MetroRail runs for 32 miles, connecting downtown Austin and northern suburbs. The railway has a good number of weekday ridership. However, the “red line” only connects a small part of Austin and the East Austin residents do not benefit from the Metrorail. Austin is working to gain community support on Project Connect, and it would take serious time and effort to create a rail network in this central Texas city. Dallas Area Rapid Transit (DART) manages several rail lines in Dallas and Fort Worth area. The service includes four light rail lines and two commuter rail lines. Houston and Dallas are absent in rail service. In Louisiana, East Baton Rouge Redevelopment Authority (EBRRA) is proposing train connecting Baton Rouge and New Orleans. In all, the twin megaregion does not have a comprehensive rail network, and the current rail lines only serve within their metro areas. There is plenty of room for improvement in promoting rail travel and multi-modal connection.

Supply-side Transportation Strategies

Transportation supply is defined differently than general market supply as it refers to the total capacity of a geographically defined transportation system in a period. According to Rodrigue and Notteboom (2017), the capacity of the transportation network can be divided into “Static” and “Dynamic” capacity. Static capacity is the space that transportation infrastructures take up, while the dynamic capacity is the flows that people travel between links. Through technology and management strategies, the network can improve dynamic capacity and increase the flow of traffics. They also stress that transportation supply and demand are “reciprocal but asymmetric”. Highways and urban roads are built to match the current needs of the transportation, but the supplies may not materialize, or the demand will outgrow supply due to population growth. Some roads or public transit lines are over-supplied as the prior demand studies appear to be optimistic or biased.

Regional Railway Case Studies

Sounder Commuter

Sounder commuter rail in Seattle Washington is one of the “new start” railways built across the United States. It consists of two lines: south line from Tacoma to Seattle downtown and north line from Everett to Seattle. The train first started in 2000 and only provided one round trip per day. The total service population for Sounder Commute was at 2.7 million in 2010. (Brock and Souleyrette, 2013) Currently, the population of Austin MSA and San Antonio MSA is well over 4.5 million. If there were any commuter rail built between Austin and San Antonio, the service population would exceed 2 million.

Sounder rail can be an example for rails connecting suburban communities and city center or between San Antonio and Austin.

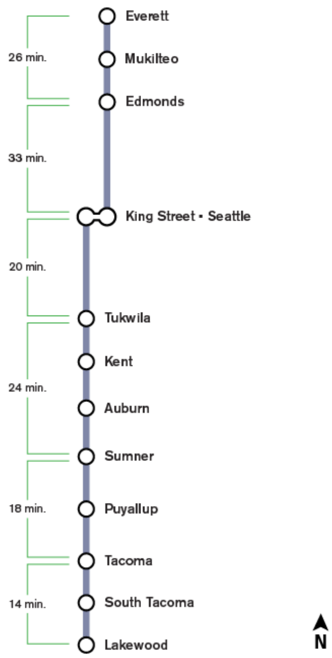


Figure 3-1: Sounder Commuter Rail Station Map

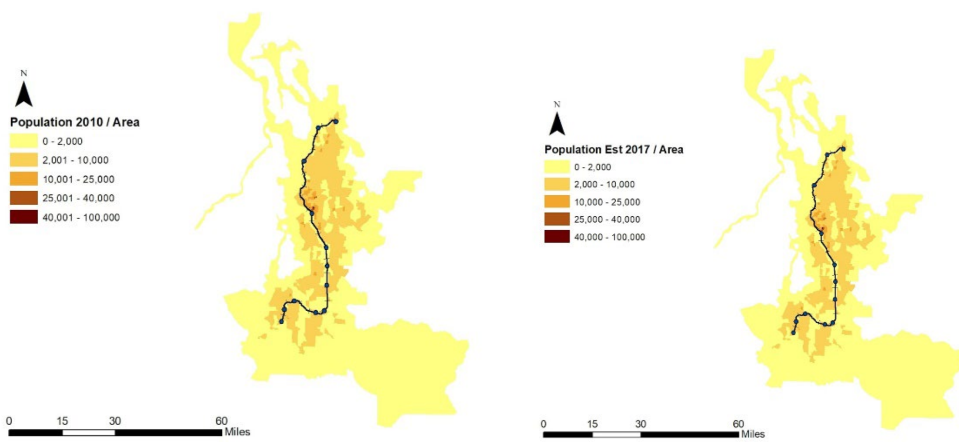
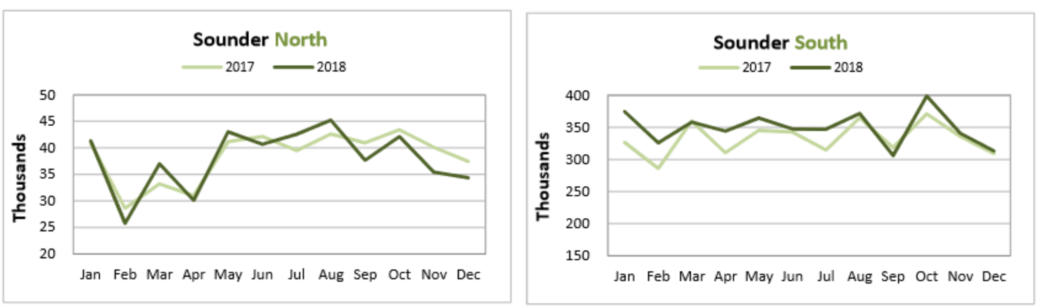


Figure 3-2: Population Density in the Puget Sound Area (2010 and 2017)

In 2011, the annual ridership for Sounder stood at 2.5 million. By 2018, Sounder has reached an annual ridership of 4.6 million with a 4.5% increase compared to 2017.
The south leg of Sounder links Tacoma and Seattle and has nine stops in total. The north leg of Sounder connecting Everett and Seattle has two intermediate stops. The north line is prone to outage due to landslides. Sounder connects two of Seattle's neighboring cities and offers affordable housing options to workers in central Seattle.
From the population density map, the south line travels a longer distance, and it covers a greater population. The north line is built along the shore of Puget Sound. Most residents would have to drive or take public transit to reach the station. The south line travels through major communities, and the stations cover a number of neighborhoods with ease of accessing the commuter rail. The combination of frequency of stops and accessibility to stations causes ridership differences between south and north. (Figure 3-3) The total volume in the south was about ten times as much as the north. The ridership of Sounder North had decreased from 2017 while the Sounder South has shown a slight increase.



Sounder North ridership decreased by 8.3% compared to last year. Average weekday boardings decreased by 10.5%.

Sounder South ridership increased by 1.3% compared to last year. Average weekday boardings increased by 9.8%.

Figure 3-3: Sounder North and South Ridership

Figure 3-4 indicates that areas that are located outside Sound Transit jurisdiction have a higher percentage of super commuters. In 2010, areas along the Sounder line showed a smooth distribution with between 10% to 20% of super commuters and the areas further away from the station areas have a higher percent of super commuters. In 2017, the percentages of super commuters had increased drastically for outside neighborhoods. Although communities around the lines have also increased in their percentages, they showed smaller increment than the outer regions. The city of Edmonds has seen a sharp increase in super commuters as it is only one stop and a little over thirty minutes away from Seattle.

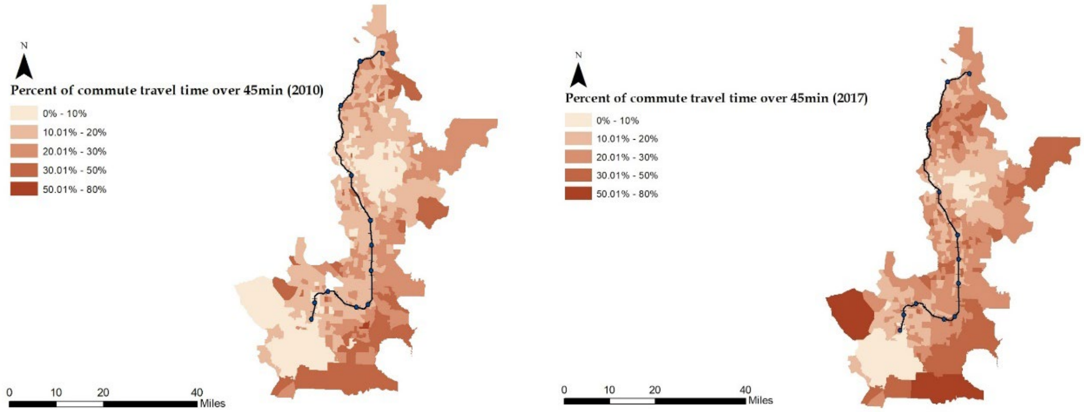


Figure 3-4: Percentage of Commute Travel Time over 45 Minutes (2010 and 2017)

Figure 3-5: 2017 Commuter Mode Share

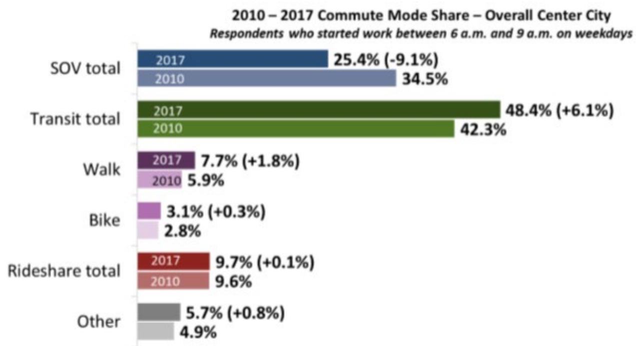


Figure 3-6: Mode Share Changes from 2010 to 2017 (Seattle City Center) (Source:)

According to a survey by Commute Seattle, the commute share for workers working in central Seattle are shown above. 9% of workers take rail or train to get to work, and 37% of workers use bus for commuting.

Figure 3-6 shows that from 2010 to 2017, the SOV mode has dropped by 9.1% while the share of transit went up by 6.1%. With the presence of rail and bus, it slows down the rate of car mode.

The rail percent map (Figure 3-7) also confirms the previous ridership comparison. Areas with a high percentage of rail commute trips are clustered in the south of Sound region. The station area in the north would have a slightly higher percentage than their adjacent places. In 2017, the percentage of rail commuting trips went up across the region and Sounder rail has become a popular mean of commuting. The growth in the south is faster than the north as the commuter rail has become impactful to broader regions. Meanwhile, the north did not present any ripple effect in attracting more areas to take commuter rails.

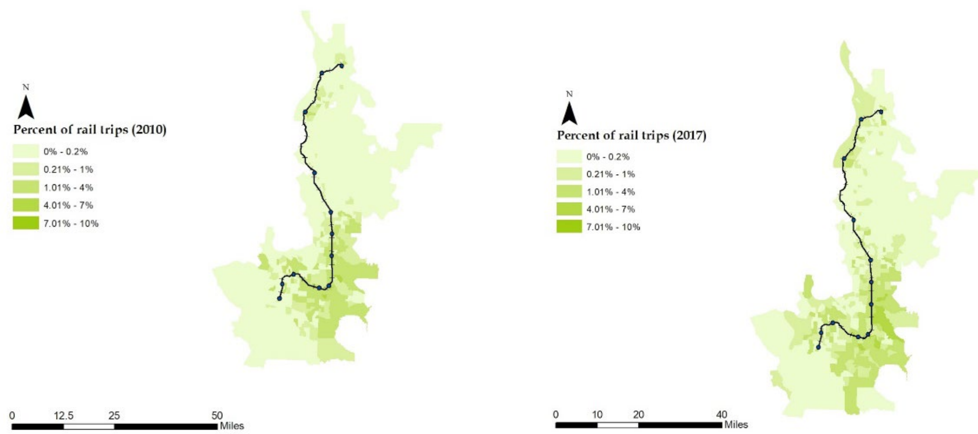


Figure 3-7: Percentage of Rail Trip to Work (2010 and 2017)

Since 1993, Washington State has adopted Commute Trip Reduction (CTR) law and counties and cities with serious congestions would collaborate with employment site with over 100 workers to establish a program in reducing drive-alone trips to work. According to the CTR board, the program reduced the drive-alone rate by 4.8% and workers' VMT by 5.6% from 2007 to 2010. The Puget Sound Regional Council also claimed that the program had saved 12,900 hours of delay and 99 million dollars of value of travel time and worth of fuel between 1993 and 2009. (Cotton et al., 2012)

Another study from Commute Seattle revealed another trend with CTR. They indicate that the CTR affected areas have reached saturation in SOV and public transit, while the non-affected area has seen a surge in public transit usage. The growing rate of walking in CTR affected area suggests that more employees starting to locate within walking distance of their offices. For non-affected areas, the market mechanism seems to work well in alternating the mode share of commuters, where many would choose public transit when they have that option.

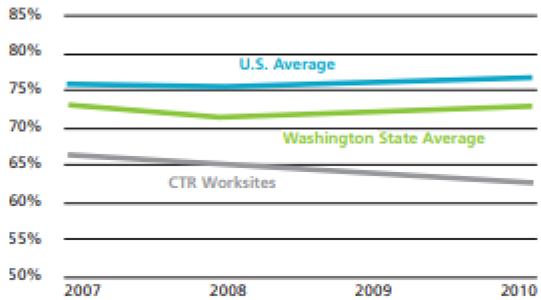


Figure 3-8: Drive-alone Rate Comparison among CTR Worksite, State and National Average (Source: Cotton et al, 2012)

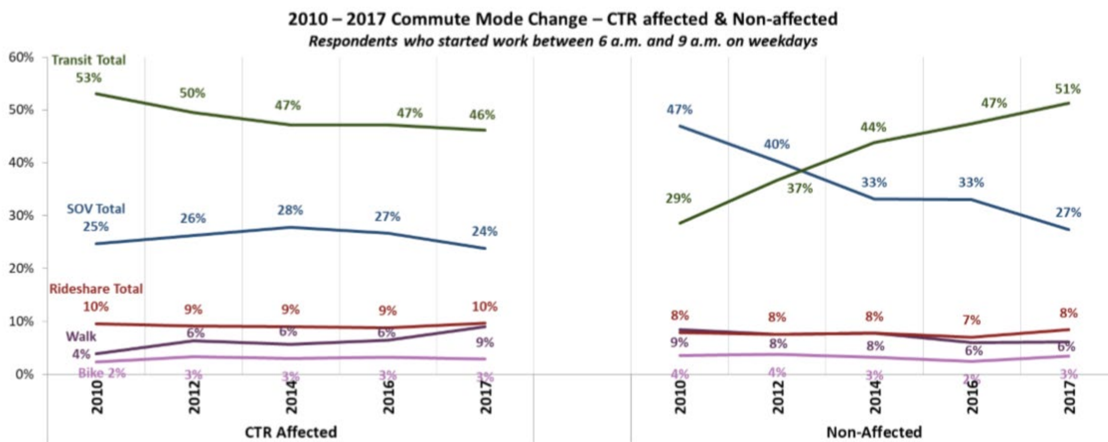


Figure 3-9: Comparison of Commute Mode between CTR Affected Area and Non-Affected Area (Source: Cotton et al, 2012)

MARC Train

MARC Train administered by Maryland Transit Administration is one of the "legacy" railway first built in 1827. It started modern operation in 1984. MARC train is classified as a heavy rail that serves in Baltimore- Washington D.C. Metro area. MARC Train consists of three lines: Brunswick Line, Camden Line, and Penn Line. Brunswick Line runs between DC and Frederick/ Martinsburg on the west and lasts for 74 miles. Camden Line is sets of 39-mile tracks from DC to Camden Station (Baltimore). Penn Line (77 miles) use Amtrak's tracks and go north to Perryville Station. Its MSA population is over

8 million and service population was 2 million by 2010. (Brock and Souleyrette, 2013) MARC train can go as fast as 120 mph, which is the fastest train in the US. The case of MARC train would apply knowledge for Central Texas in opting in HSR to connect Houston and Dallas and further introduction for HSR.

Figure 3-10 indicate that people cluster around major cities, Washington DC and Baltimore, and in small towns like Frederick, College Park and Fort Meade. The population density did not change much from 2010 to 2017, with exceptions of outliers and denser urban centers. The cluster of cities seems to be a bigger factor than the location of stations in affecting population density.

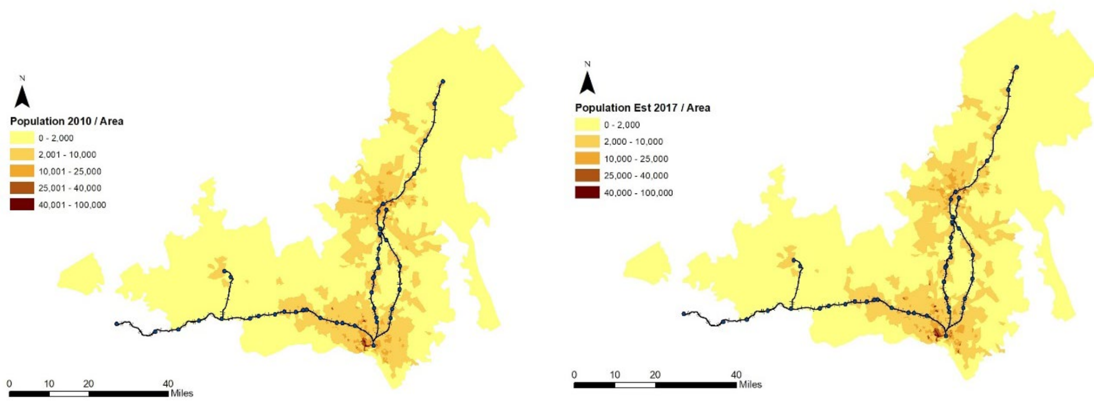


Figure 3-10: Population Density around MARC Line Area (2010 and 2017)

City center areas have lower percentages of super commuters than suburban communities. In 2010, the suburban areas in the east and west of DC had over 50% of super commuters, and in 2017, the situation persisted. For these communities, they have poor access to commuter rail, and most of them have to drive or use bus and transfer to subway if they want to travel to worksites in DC. These areas have proven to be less balanced in terms of housing and jobs. Communities along the Penn Line and Camden Line seem to perform better than the Fairfax or Annapolis regions.

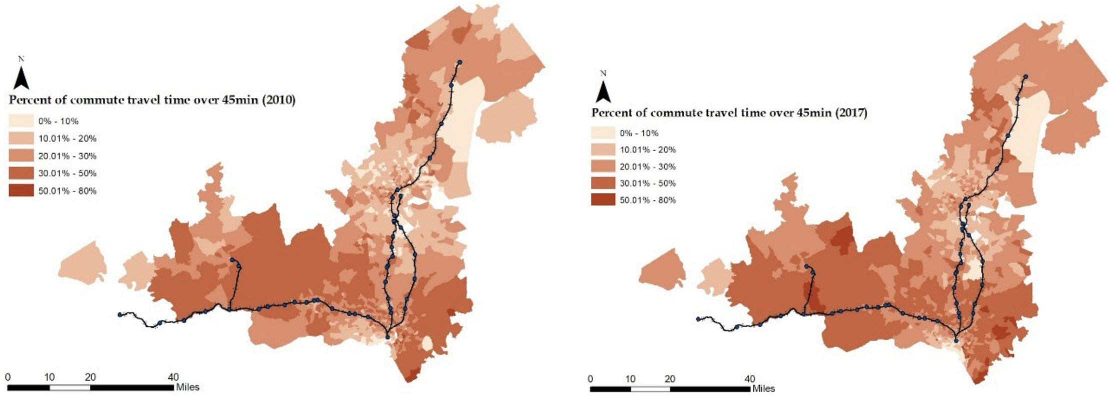


Figure 3-11: Percentage of Commute Time over 45 Minutes (2010 and 2017)

As for the percentage of rail commuting trips, it is high for areas remote stations. (e.g., Aberdeen and Harpers Ferry)Tracts within Baltimore and DC center have lower percentages as workers prefer flexible options of buses or subways. Subdivisions between Baltimore and DC also have a higher percentage of rail trips. In 2017, areas near Brunswick line had a higher share of rail trips, and the same happened in between Baltimore and DC.

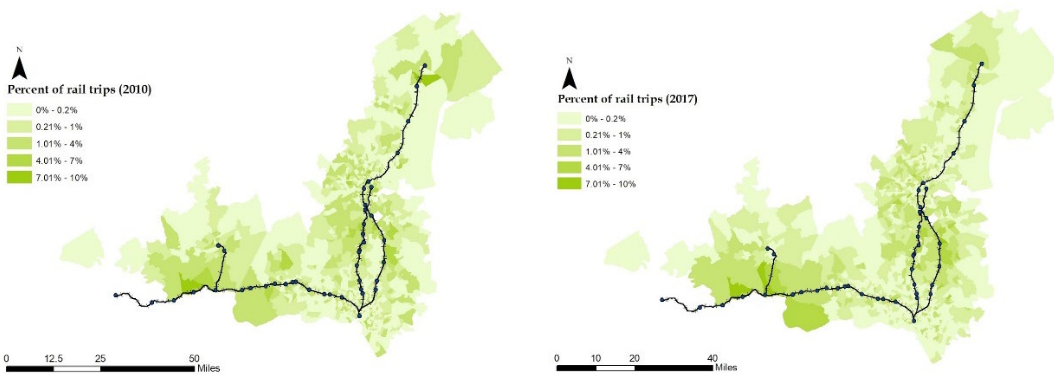


Figure 3-12: Percentage of Commuter Rail Trip (2010 and 2017)

According to MDOT's performance report, the ridership for MARC train remain stable and it has seen a minor increase over seven years. On the other hand, heavy rail (Baltimore Metro) and Light rail have a negative rate of change from 2012 to 2018. In

DC, its metro also suffered from a decline in ridership. The drop in Baltimore Metro wad due to a SafeTrack program which resulted in the reduction of services and lengthy system maintenance. Meanwhile, the agency was reluctant to improve service hiring more workers due to budget issues. The board also mention that ride-hailing app also affects their weekday ridership. (Kimbrough, 2019)

Even though the rail transit in Baltimore and DC become less attractive, the commuter rail (MARC train) remain steady in its ridership over the years. The demand from daily commute and weekend travel in the region is high, and it supports MARC train even though other rail transit was declining.

TABLE 3-1: ANNUAL RIDERSHIP BY TRANSIT MODE (SOURCE: MDOT, 2018)

FISCAL YEAR	2009	2010	2011	2012	2013	2014	2015	2016	2017*
TRANSIT RIDERSHIP–MTA DIRECT-OPERATED SERVICES (THOUSANDS)									
LOCAL BUS	75,694	74,926	78,390	79,535	80,071	75,780	78,697	75,619	69,587
BALTIMORE METRO	13,567	13,364	14,588	15,364	15,208	14,632	13,901	12,222	10,960
LIGHT RAIL	8,644	8,158	8,655	8,540	8,647	8,106	7,657	7,431	7,414
TRANSIT RIDERSHIP–CONTRACTED SERVICES AND LOTS (THOUSANDS)									
MARC	8,021	8,096	8,233	8,452	9,062	9,168	9,246	8,962	9,185
CONTRACTED COMMUTER BUS	3,974	3,859	4,097	4,290	4,187	4,017	4,034	3,928	3,866
MOBILITY PARATRANSIT & TAXI ACCESS	1,450	1,481	1,660	1,900	2,084	2,289	2,495	2,556	2,746
LOTS	45,635	45,700	40,243	40,908	40,281	42,500	39,441	38,476	39,818

** 2017 data is preliminary and subject to change.*

TABLE 3-2: ESTIMATED TRANSIT PASSENGER TRIPS YEAR-TO-DATE CHANGE (SOURCE: AMERICAN PUBLIC TRANSPORTATION ASSOCIATION 2015, 2016, 2017 AND 2018 FOURTH QUARTER RIDERSHIP REPORTS)

Percent Change	Type	2015	2016	2017	2018
Baltimore	Heavy Rail	-11.04%	-13.18%	-3.82%	-23.51
	Light Rail	-14.88%		-6.1%	-2.68%
	Commuter Rail (MARC)	-2.29%	-1.85%	3.34%	-0.47%
Washington DC	Heavy Rail	-3.59%	-10.41%	-1.98%	-1.41%
	Light Rail		N/A	58.95%	-3.33%

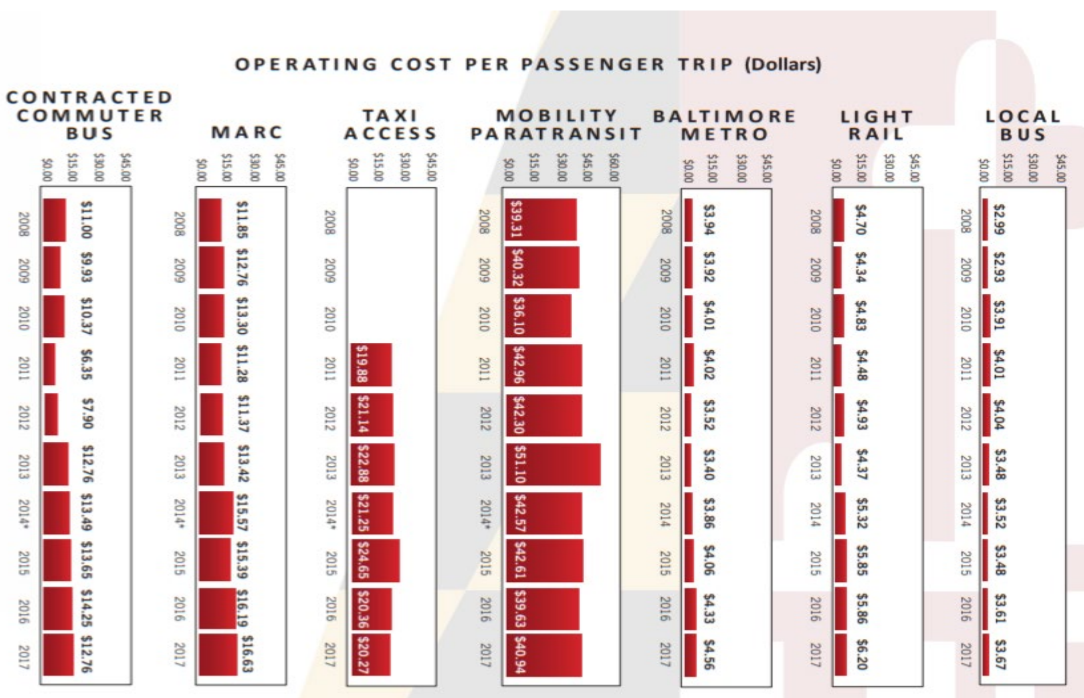


Figure 3-13: Operating Cost per Passenger Trip (SOURCE: MDOT, 2018)

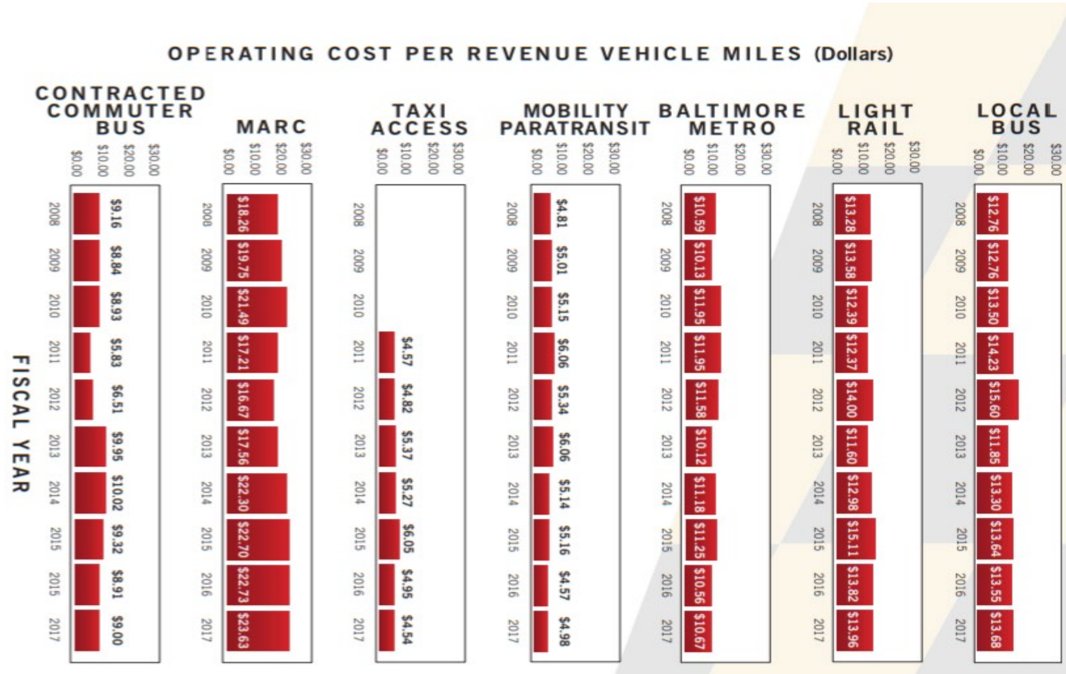


Figure 3-14: Operating Cost per Revenue Vehicle Miles (SOURCE: MDOT, 2018)

Since regional railway travels long distance with more cars, it costs more for regular maintenance and operating. Graphs from MDOT could provide insight about the operating costs of different type of transit. MARC is the third highest in operating cost per passenger trip and highest in operating cost per revenue miles. If these operating costs were split among passengers, the operating cost per capita would have come down. The major takeaway from this is that regional train service should increase its on-board passengers as many as possible by providing better connections to the workplace and residential places. In MDOT's report, it mentions "providing maximum capacity" for areas with high demand potential to accommodate future travel demand. (MDOT, 2018)

COMMUTING PATTERNS IN THE TWIN-MEGAREGIONS

This chapter delves into the commuting pattern of the two-state. As super commuters or inter-city commuters are regular divers on the route, cheap and stress-free options would appeal to them. Also, many rail lines in Texas and the US were first built for daily commute, so it would be a useful aspect to learn where the corridors are and what type of transit the megaregions need. The first half will extrapolate the past and current trends of commuting patterns in Texas and Louisiana. Some of the busy commuting lines will be identified. The latter half will explore the current status of super commuting and its implication to the regional transportation system.

Although commuting data among counties is easy to acquire on the census bureau website, there are no substantial studies done on the commute patterns in the twin megaregion combined. Perkins(1999) had done a commuting pattern and trend analysis in Texas. He identified the factors influencing the commuting flows are population growth, worker growth, availability of vehicles and household income. He stressed that growth in population, growth in employment and increase in vehicle availability are three countering factors. If one grows faster than the others, it will become the prime factors for commuting change. Nowadays, the commuting behaviors are getting complicated. The study is somewhat outdated, and a new model for predicting commute trend needs to be introduced. McKenzie (2013) has analyzed the county-to-county patterns in the United States using 2006-2010 ACS commuting data. He sorted some of the critical county-to-county commutes shed, such as Fort-Bend County to Harris County and Williamson County to Travis County. The study highlights some of the commute flows that have seen the most significant increase or indicates the trend about out-of-country commute is emerging.

Overall, county-to-county commute studies are relatively preliminary. They focus on the description and interpretation of the data, but there are not a lot of studies done on the correlations between county-to-county commute trends and socioeconomic correlations.

Analyzing Commuting Pattern

The data used for commuting flow analysis is downloaded from the US census bureau. The table used is US Census commuting flow in 1990 and 2000 and 2009- 2013 flows data. The data that downloaded are flat tables. After selecting trips that start or end in Texas, I converted the tables into ".bin" files and imported them into the matrices.
The desire lines are drawn using the "desire line" function in TransCAD. As the matrices for commute flows (AB and BA) are created, desired line procedures are performed to draw the flows of commute among counties within the whole Texas. Once I got the AB/BA values for each county, the map results would show up. For the commuting flows, the map represents the dual flows of commutes within Texas and Louisiana. The study also takes into account the external trips as they are crucial to determining the ridership of HSR.

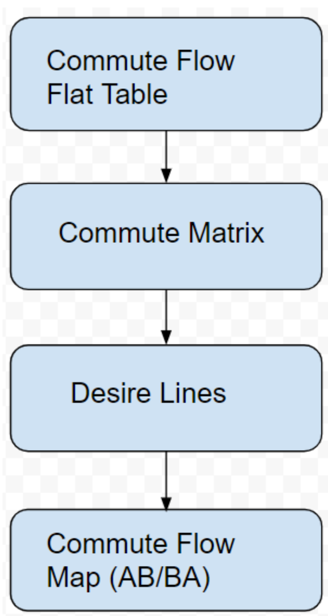


Figure 3-15: Workflow of Commute Analysis

Commuting Findings

To clearly present the inter-county commuting patterns, the analysis filtered out pairs with daily flows less than 1000 trips. According to Figure 3-16, Figure 3-17 and Figure 3-18, there is a dense distribution of commuting flows in Texas and Louisiana. Dallas-Fort Worth area has seen the largest flows, especially between Dallas and Tarrant county. Houston-Galveston area is also large in commuting flows. Austin- San Antonio area has fewer flows than the prior two metropolitan areas. In Louisiana, there are a high volume of flows around New Orleans

The commuting flows delineate the boundaries of the Texas Triangle, and the lines around the four major anchor cities are much thicker than others. Over 13 years, more lines were developed, and workers were commuting longer distance to anchor cities. In the Austin area, more lines have appeared from 1990 to 2013. Only a few lines travel in and out of Travis County in 1990, and 13 years later, significant commuting flows emerged on the west of Austin connecting Burnet and Llano County.

The four anchor cities have a higher employment density, and as a result, they tend to attract more workers near the area. For residents, anchor cities have a bigger residential base, and more people reside in them. In the Houston-Galveston Area, more workers live further away and travel long distances to get to Harris County. Figure 3-21 shows new flows connecting Wharton County and Walker County, which previously did not have significant flows to Harris County. Other than workers from rural counties traveling to anchor counties, rural counties have proven to become increasingly interconnected. Cooke and Grayson County, which did not have a high volume of commuting flows before have increased in flows between them. The same pattern can be observed in other regions as well.

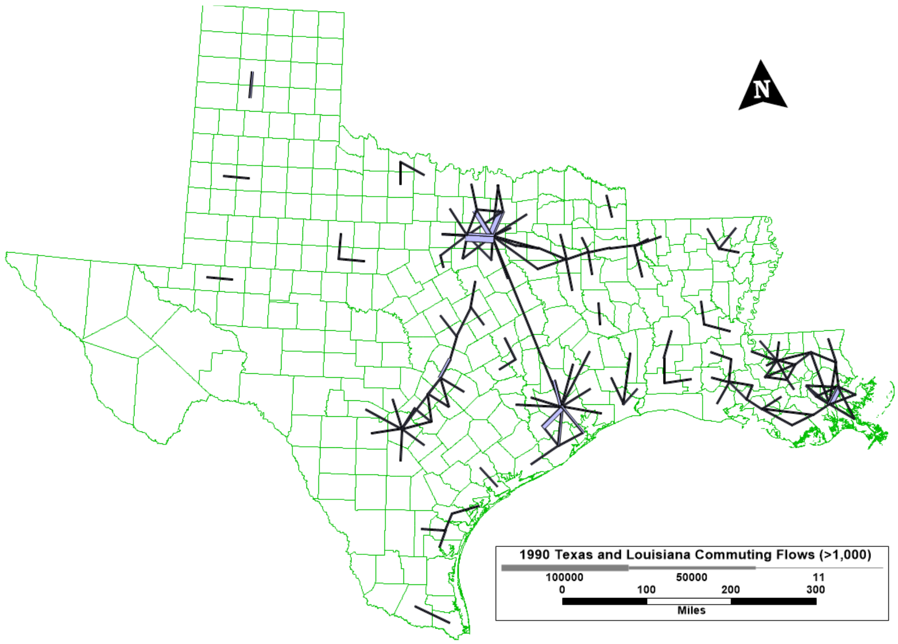


Figure 3-16:1990 Texas and Louisiana Commuting Flows (>1,000)

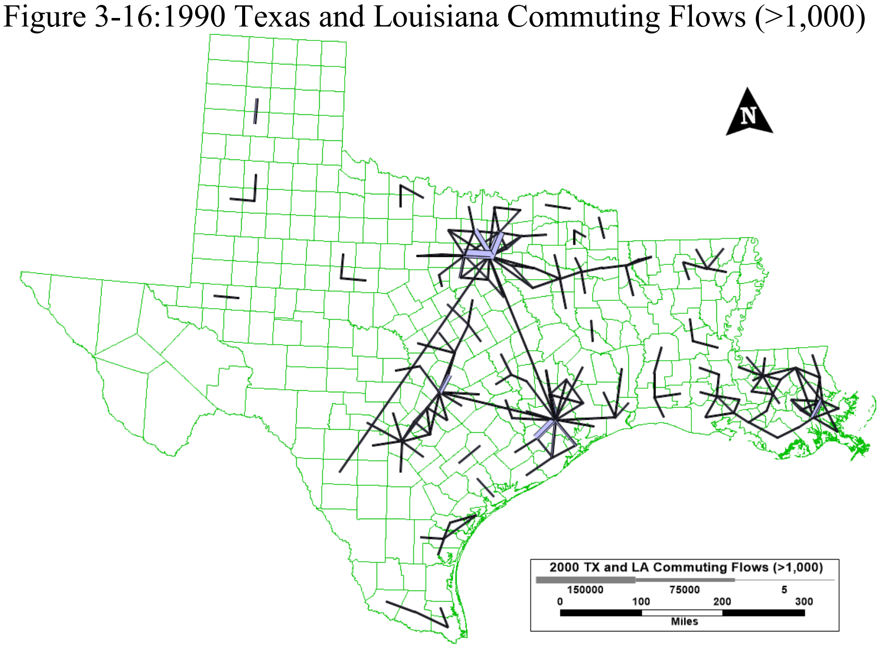


Figure 3-17: 2000 Texas and Louisiana Commute Flows (>1,000)

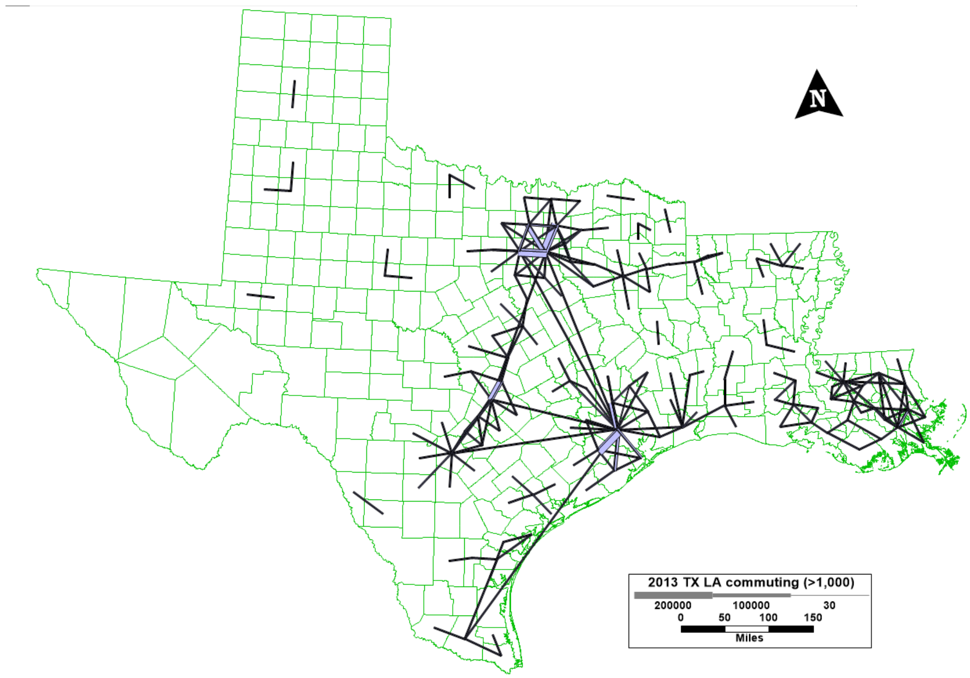


Figure 3-18: 2013 Texas and Louisiana commute (>1000)

Super Commuting

According to Moss and Qing (2012), the “Super Commute” trend has been constantly increasing over time. In one of the updated version of the report, Texas became the “epicenter” for super-commuting growth, with 13% of the workforce of Dallas and Harris Counties living outside the combined metropolitan area. Also, Houston-Dallas route has become the busiest line for super-commuters, overtaking the Arizona “Sunny Corridor” Route. (Moss and Qing, 2010) In 2009, almost 52,000 residents of Dallas Fort Worth worked in Houston. Dallas is also a top destination in the states for super-commuters from Austin and Houston.

In Texas general, the number of extreme commutes (longer than 90 minutes) increase by 39% from 2010 to 2015 according to PEW(2017). From the analysis, Austin MSA and San Antonio MSA have a higher rate of super commuters compared to all out-of-county commuters. Dallas and Houston MSAs have a higher number of super commuters(26,098 and 28,937 respectively in 2010). In terms of the growth in super-commuter percentage, Austin, Dallas and Houston have much doubled the rates than that of San Antonio.

The reasons for supper commuting can be complicated. Some are escaping from unaffordable housing; some are searching for better schools for the kids; others might look for real estate interests out of certain areas.

In tech job centers like Seattle and San Francisco, low-income workers are moving farther away while high-income workers can still afford to live close to work, according to a 2015 Zillow study that looked at changes through 2014. “While commute times for higher-income earners hasn’t changed much over the past ten years, commutes are getting longer and longer for low-income workers,” said Lauren Braun, a Zillow spokeswoman.

In this section, I take flows that start or ends in four MSA with distance longer than 50 miles as supper-commute flows and calculate their proportions to all commuting flows. Table 3-3 presents the growth of percentages of super-commuters as to total commuters. Houston and Dallas MSAs have lower supper-commuting rates than Austin MSA.

If we take commute trip from San Marcos to San Antonio for example, as defined being supper-commute, it only takes 50 minutes to commute, which is a reasonable time for a lot of commuters. The supper commute rate in Austin and San Antonio MSAs are high because they are adjacent regions with short distances. Another study from metro magazine suggests that super commuters are less likely to drive to work. In the top 10 cities with the highest super commuter rates, less than 70% of them would drive to work. (Table 3-4) (Bennet, 2018) It is noticeable that these cities are in regions with a well-rounded public transit system, so they can take a longer time to work without focusing on the road. However, with the current road network in the South, super commuting during rush hour in megaregion is costly in time and fuel. As commuters are taking regular long-distance trips, opting in an alternative transportation mode would help improve traveler’s enjoyment and levitate transportation system.

TABLE 3-3: SUPER-COMMUTE PERCENTAGE AND RATE OF CHANGE (CALCULATED FROM ACS 2000 AND 2010 DATA)

Super Commute percentage	2000	2010	Growth Rate
Austin	15%	17.80%	64%
Dallas	5.50%	6.90%	60.00%
Houston	8%	8.50%	61.20%

TABLE 3-4: PERCENTAGE OF SUPER-COMMUTERS DRIVING TO WORK (SOURCE: BENNET, 2018)[3]

Rank	Regular Commuters	Super Commuters	Difference
1	95.40%	47.90%	47.50%
2	93.80%	58.30%	35.50%
3	92.40%	59.60%	32.80%
4	91.00%	58.70%	32.30%
5	61.40%	31.50%	29.90%
6	91.80%	62.40%	29.40%
7	95.80%	68.30%	27.40%
8	83.50%	57.20%	26.30%
9	86.30%	61.40%	24.90%
10	93.70%	70.20%	23.50%

Major Corridors in Twin Megaregions

As established earlier, this study has identified that about 81% of long-distance trips generated from Texas travel to destinations within Texas and 63% of Louisiana long-distance trips travel within the state according to NHTS 2001 long trip file. For super

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[3] Ranking for top 10 cities: Stockton, CA; Modesto, CA; Riverside, CA; New York; Bridgeport, CT; San Francisco, CA; Washington, DC; Allentown, PA; Atlanta, GA, Los Angeles, CA. https://www.metro-magazine.com/management-operations/news/729584/super-commuters

commuters, about 69% of Texas commuters travel to work destinations within Texas every day (Calculated from commuting data ACS 2009-2013).

To identify super commute flows within Texas and Louisiana, the total commute trips from the long trip table are distributed proportionally according to 2013 commute flow. For example, Acadia County in Louisiana will generate 9278 commute trip per month by 2035 and 9278 trips are divided by proportionally to destination counties based on 2013 ACS commute flows. Ascension has received 27 commute trips from Acadia, so flow from Acadia to Ascension would be roughly at 144.88 per month or 1739 per year. There are 4.6 million commute trips generated in Texas annually, and 61% of them (about 2.8 million) are commute travel within the state. I used the multiplication method to distribute these commuting trips by proportions from 2013 ACS commuting flows. The flow map below shows commuting flows larger than 25 thousand annually within Texas.

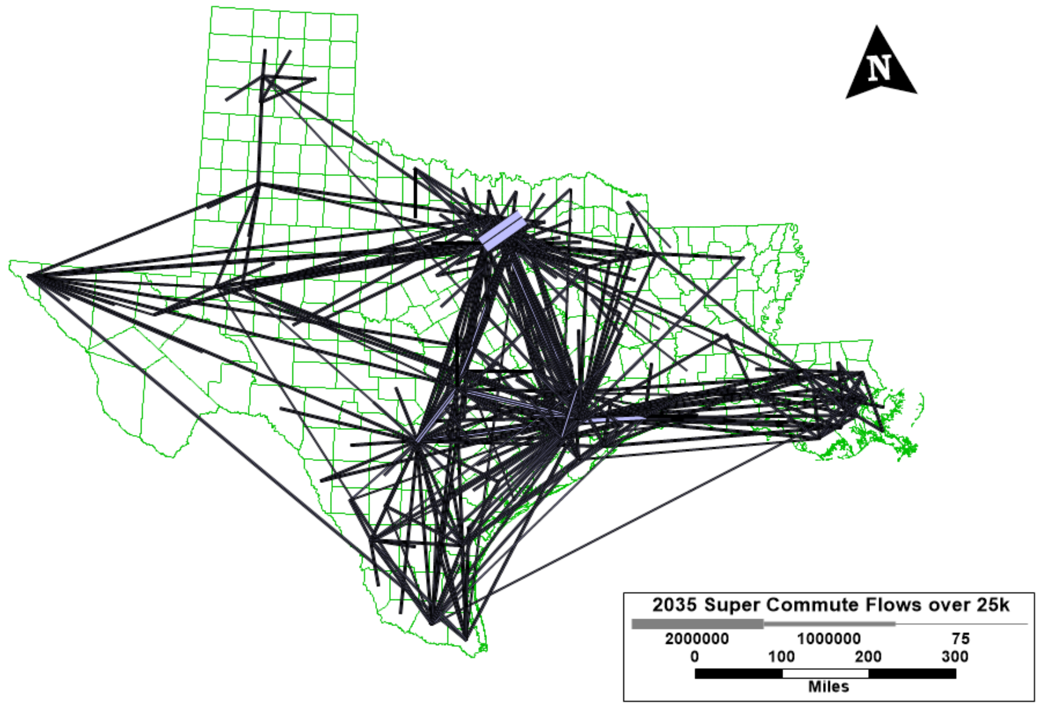

Figure 3-19: 2035 Projected Super Commuting Corridors in Twin Megaregions

These flows can be categorized into two different trips: median-distance commuting trips (relatively long, but the origin and destination remain in one or adjacent metropolitan area) and mega commute trips (travel across several metro areas). From the analysis, about 23% of the commute trips are mega trips, and the rest are median-distance trips. When looking at typical mega commute corridors (top five corridors among all), I have found an interesting pattern that they are all trips travel to and from anchor cities in the Triangle. In Table 3-5, these top corridors are among Dallas, Houston, Austin and San Antonio Metro areas. It again confirms that these four anchor cities have been the transportation and business hub for the state. Other than the Triangle, favorite origins and destinations for commuters are Gulf Coast (Nueces, Camero County), Far West (El Paso and Midland) and East Louisiana (East Baton Rouge and Jefferson). (Table B-1)

TABLE 3-5: TOP INTER-MSA COMMUTE FLOWS

A Name	B Name	A to B	B to A
Dallas	Harris	736,876	697,469
Bexar	Harris	367,802	396,082
Harris	Travis	442,975	362,716
Bexar	Dallas	223,646	311,976
Dallas	Travis	396,190	313,434

As for median-distance trips, most commuters are traveling from out-of-metro areas to metro areas. From a typical residential street to Fort Worth Convention Center would cause about 1.5 hours during non-rush hours. (See Figure 3-20). Some of the commuters travel to Fort Worth while some of them travel to McKinney. Next couple of pairs are not as symmetrical as the prior one, as most of the commuters travel from their "Bedroom" communities to their workplace. As a result, the flows in one direction is high, whereas the opposite direction is too low. An example is a trip from a small town called Cleveland in San Jacinto to Uptown Houston. (Figure 3-21) It would take about 1 hour and 40 minutes to get to work. These super-commuting trips could be made by workers daily, and a better solution instead of driving alone can take away some of the congestions in the city.

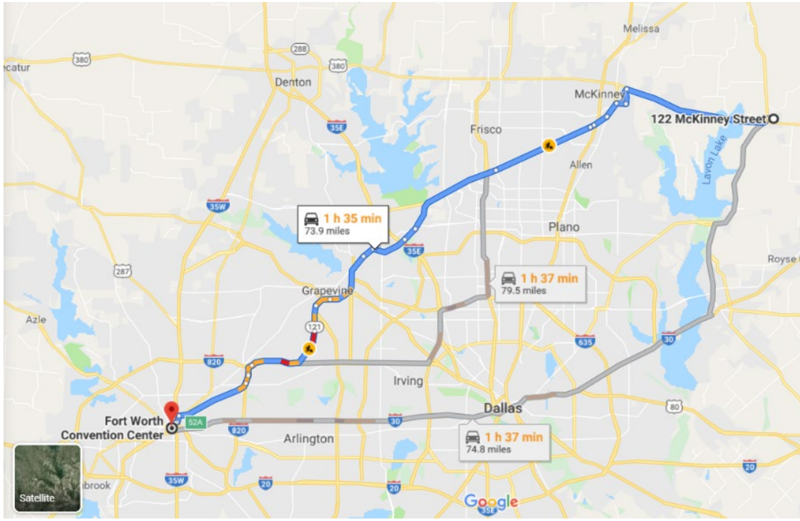

Figure 3-20: Collin County to Tarrant County Commute

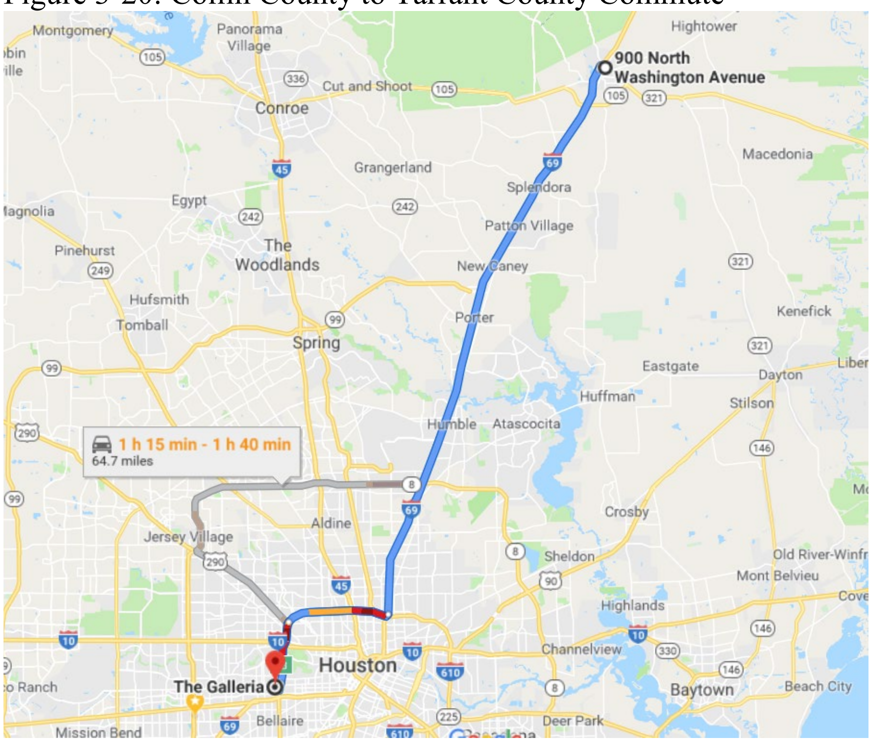

Figure 3-21: San Jacinto County to Harris County Commute

TABLE 3-6: MEDIAN DISTANCE COMMUTE FLOWS

A Name	B Name	AB	BA
Collin	Tarrant	1,690,782	1,931,924
Dallas	Van Zandt	106,225	64,881
Dallas	Henderson	18,899	290,645
Dallas	Grayson	73,209	81,510
Harris	San Jacinto	N/A	39,367
Bexar	Travis	511,702	575,333
Dallas	Parker	99,526	178,451
Harris	Jefferson	938,305	192,659
Bexar	Hays	268,886	273,457
Dallas	Wise	77,037	79,268
Austin	Harris	56,916	546,776
Harris	Polk	60,551	43,229
Bell	Travis	355,703	299,353
East Baton Rouge	Jefferson	155,219	245,303
Dallas	Navarro	118,187	44,437

SUMMARY

Although both kinds of commuting are considered “super commute” generally. They have different implications for the transportation system. The long-distance (mega commute) commutes do not typically happen every day as average workers cannot afford the time or money to commute super long distance. A common phenomenon is that they work from home for most of the time, but they have to travel to their company, which is located in a different area once in a week or month. The second type of commute is very common from the ACS data. Commute time from an hour to two hours is acceptable to some workers, so they can travel to work daily. However, the workers are faced with the dilemma that most of the places in Texas do not have a sufficient transit system for long-distance commuters. They are forced to drive without the choice of public transit.

To solve the current problem, transit agencies ought to start providing reliable long-distance transit for regular commuters, and state and joint transportation agencies should propose a long-distance rail project to accommodate future demands.

Chapter Four: Methodologies of Analyzing Travel Demands with Trip Generation and Mode Share Methods

In previous chapters, the study illustrates the needs for rail as a supply-side solution of increasing long-distance travel demand. Chapter Four's quantitative findings indicate that supper commuting employees are growing, and the megaregions does not have sufficient public transit options to accommodate their needs. Instead of the commute trips, the latter part of the study uncovers the travel needs of all travel purposes. This chapter starts with obtaining the trip generation rates for a different classification of household based on NHTS 2001 long-distance trip file. The households in NHTS 2001 long file are divided into different sizes and income classes, and the analysis would provide results in trip rates differences by household sizes and income classes. The trip rate table can be converted to total trip generated table when multiplied by total household number by category.
In the literature review, NCRRP 4 provides a powerful tool to calculate the aggregated mode share. By inputting the demographic percentages from NHTS 2017 and travel time and cost index, one can easily calculate the mode share of the region. Subsequently, the study estimates the number of long-distance trip monthly from the trip rate table.

Trip Generation

The trip rates are calculated from the NHTS 2001 Long-trip table. The trip rates by household size and median family income were calculated from average trips every 30 days by each household and average trips made in those 30 days for each income-household size pair. First, the long trip table was imported into TransCAD for following operations. Then eight new columns were created in this table for coding purposes. "HHMINC," "HHSIZE_1" and "HHINC_SIZE" represent the classifications of household median income, household size, and the income-household pair. "Purp_1" to "Purp_4" and "Commute" are five different purposes. (See Figure 4-1) Commute purpose is already included in the business purpose, but it is separated for analysis in the later chapters.

As discussed in the early chapter, the coding of the following four purposes are based on the purpose surveyed from NHTS table. Although FARREA21 column provides general purposes categories, they do not fit the concurrent study. The trips are divided by purpose based on the column FARREAS1, which is the first purpose of taking the trip. In FARREAS1, trips of “01”, “02” or “03” values are considered Business trips in our new categorization, and “05”, “07”, “08” or “09” are coded as Vacation. Visit trips are accounted for by cells with “06”, “15” or “18”. The rest of the cells are assigned as Others. For Commute trips, FARREAS1 identifies commute trips for those trips with values of “01”.

In TransCAD, the table is grouped by Household ID and sum values of all five purposes. A table with Household ID as unique ID would be produced, and the number of trips made by that household for each purpose is summed in that row. The new table is grouped again by Income-Household Size pair next, and the number of trips is calculated by averaging across all households. The average values are the trip rates for the long-distance trip made by each household for 30 days. There are positive correlations between the trip rates and income and household size. Some unusual patterns are presented in the first income group, but the graphs follow the general pattern.

To better capture the long-distance trip generated from the Texas Triangle, this study uses Texas and Louisiana as study areas for trip generation and distribution. Household characteristics, household by income and household size in 2000 and 2017 are downloaded from social explorer. There is no matching census in the year 2001, so 2000 decennial census are used to represent the household condition in 2001. American Community Survey 2017 is also downloaded to match NHTS 2017. Income class and household size are simplified by five classes instead of the original classification. The projection tool used was simple regression, where the number of households in 2017 is subtracted from 2001 households, and the values are divided by 16. Next, the increments or declines per year are multiplied by 18 and added by the households in 2017. See below formula:

$$HH_{2035xy}= (HH_{2017xy}-HH_{2001xy})/16*18+HH_{2017xy}$$

Where x is the household size class, and y is the household income class

Dataview1 - Long Distance trips file

HOUSEID	PERSONID	TPTRPNUM	Purpose	Purp_1	Purp_2	Purp_3	Purp_4	Commute	HHMINC	HHSIZE_1	HHINC_SIZE
10000577	1	1	1	1	0	0	0	0	5	2	52
10000577	1	2	1	1	0	0	0	0	5	2	52
10000894	1	1	3	0	0	1	0	0	5	2	52
10000894	1	2	3	0	0	1	0	0	5	2	52
10000894	2	1	3	0	0	1	0	0	5	2	52
10000894	2	2	1	1	0	0	0	0	5	2	52
10000894	2	3	1	1	0	0	0	0	5	2	52
10000894	2	4	1	1	0	0	0	0	5	2	52
10000894	2	5	3	0	0	1	0	0	5	2	52
10000894	2	6	1	1	0	0	0	0	5	2	52
10000894	2	7	1	1	0	0	0	0	5	2	52
10000894	2	8	1	1	0	0	0	0	5	2	52
10000894	2	9	1	1	0	0	0	0	5	2	52
10000894	2	10	1	1	0	0	0	0	5	2	52
10000894	2	11	1	1	0	0	0	0	5	2	52
10000894	2	12	1	1	0	0	0	0	5	2	52
10000894	2	13	1	1	0	0	0	0	5	2	52
10000894	2	14	1	1	0	0	0	0	5	2	52
10001079	1	1	3	0	0	1	0	0	4	2	42
10001202	1	1	2	0	1	0	0	0	1	1	11
10001574	1	1	4	0	0	0	1	0	4	4	44
10001574	2	1	2	0	1	0	0	0	4	4	44

Figure 4-1: NHTS 2001 Long Distance Trip File in TransCAD

TABLE 4-1; TRIP RATE CALCULATED FROM NHTS LONG TRIP FILE

Income	HH_Size	Business	Vacation	Visit	Others	Commute(
1	1	0.162791	0.205426	0.686047	0.453488	0.042636
1	2	0.413284	0.265683	1.04428	1.02214	0.177122
1	3	0.166667	0.341667	1.458333	0.566667	0.083333
1	4	1.780822	0.60274	2.054795	0.479452	1.684932
1	5	0.289474	0.526316	1.289474	0.855263	0.144737
2	1	0.367003	0.245791	0.79798	0.414141	0.132997
2	2	0.477407	0.374263	1.04224	0.848723	0.188605
2	3	0.748052	0.4	1.34026	0.833766	0.420779
2	4	1.166078	0.547703	1.342756	1.070671	0.646643
2	5	0.840183	0.593607	2.082192	1.547945	0.461187
3	1	0.571429	0.275132	0.666667	0.338624	0.198413
3	2	0.760396	0.466337	1.113861	0.693069	0.351485
3	3	1.091127	0.455635	1.443645	0.676259	0.561151
3	4	1.403646	0.776042	1.609375	0.976563	0.809896
3	5	1.437229	0.974026	1.800866	1.580087	0.766234
4	1	0.496183	0.316794	0.637405	0.270992	0.167939
4	2	1.059426	0.538934	1.106557	0.637295	0.404713
4	3	1.422794	0.507353	1.200368	0.911765	0.744485
4	4	1.299257	0.812268	1.615242	1	0.689591
4	5	1.44863	0.931507	1.921233	1.277397	0.818493
5	1	0.979487	0.369231	0.646154	0.220513	0.271795
5	2	1.223582	0.602448	1.093428	0.455541	0.400773
5	3	1.444727	0.701398	1.165184	0.677255	0.395172
5	4	1.302326	0.909192	1.230343	0.741971	0.417497
5	5	1.406316	1.36	1.412632	0.905263	0.496842

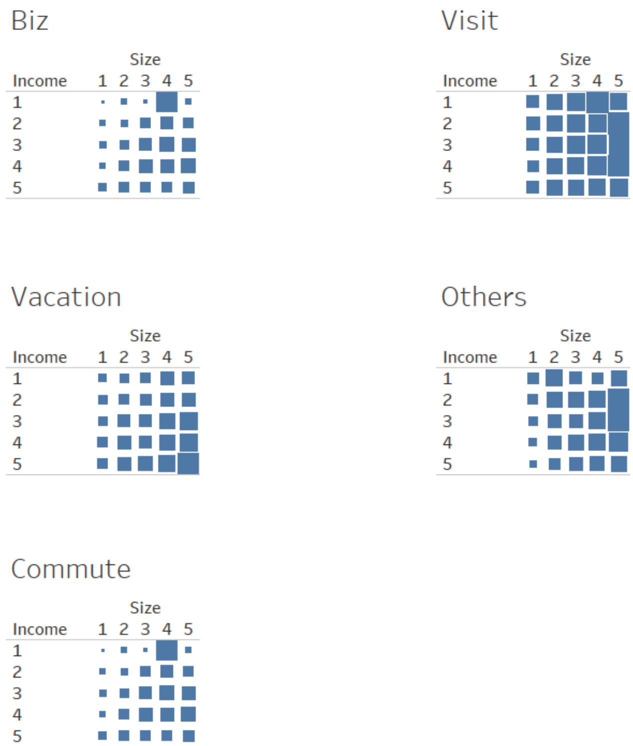

Figure 4-2: Trip Rates and Household Size and Income Class

TABLE 4-2: SAMPLE OF HOUSEHOLD PAIRS BY COUNTY

Geo_FIPS	48001	48001	48001	48001	48001	48003	48003	48003	48003	48003	48005	48005	48005	48005
INC1_Size1	583.2383	583.2383	583.2383	583.2383	583.2383	102.3526	102.3526	102.3526	102.3526	102.3526	1130.857	1130.857	1130.857	1130.857
INC1_Size2	779.3169	779.3169	779.3169	779.3169	779.3169	164.2426	164.2426	164.2426	164.2426	164.2426	1467.6	1467.6	1467.6	1467.6
INC1_Size3	298.9179	298.9179	298.9179	298.9179	298.9179	100.5587	100.5587	100.5587	100.5587	100.5587	762.685	762.685	762.685	762.685
INC1_Size4	282.2163	282.2163	282.2163	282.2163	282.2163	91.19053	91.19053	91.19053	91.19053	91.19053	687.2546	687.2546	687.2546	687.2546
INC1_Size5	235.0049	235.0049	235.0049	235.0049	235.0049	81.12469	81.12469	81.12469	81.12469	81.12469	580.8439	580.8439	580.8439	580.8439
INC2_Size1	1319.811	1319.811	1319.811	1319.811	1319.811	241.5611	241.5611	241.5611	241.5611	241.5611	2062.337	2062.337	2062.337	2062.337
INC2_Size2	1763.517	1763.517	1763.517	1763.517	1763.517	387.6268	387.6268	387.6268	387.6268	387.6268	2676.453	2676.453	2676.453	2676.453
INC2_Size3	676.4217	676.4217	676.4217	676.4217	676.4217	237.3273	237.3273	237.3273	237.3273	237.3273	1390.904	1390.904	1390.904	1390.904
INC2_Size4	638.6278	638.6278	638.6278	638.6278	638.6278	215.2176	215.2176	215.2176	215.2176	215.2176	1253.342	1253.342	1253.342	1253.342
INC2_Size5	531.7931	531.7931	531.7931	531.7931	531.7931	191.4613	191.4613	191.4613	191.4613	191.4613	1059.282	1059.282	1059.282	1059.282
INC3_Size1	753.8937	753.8937	753.8937	753.8937	753.8937	121.4466	121.4466	121.4466	121.4466	121.4466	1120.836	1120.836	1120.836	1120.836
INC3_Size2	1007.345	1007.345	1007.345	1007.345	1007.345	194.8822	194.8822	194.8822	194.8822	194.8822	1454.594	1454.594	1454.594	1454.594
INC3_Size3	386.3812	386.3812	386.3812	386.3812	386.3812	119.3181	119.3181	119.3181	119.3181	119.3181	755.9261	755.9261	755.9261	755.9261
INC3_Size4	364.7928	364.7928	364.7928	364.7928	364.7928	108.2022	108.2022	108.2022	108.2022	108.2022	681.1642	681.1642	681.1642	681.1642
INC3_Size5	303.7673	303.7673	303.7673	303.7673	303.7673	96.25858	96.25858	96.25858	96.25858	96.25858	575.6965	575.6965	575.6965	575.6965
INC4_Size1	893.3144	893.3144	893.3144	893.3144	893.3144	189.3857	189.3857	189.3857	189.3857	189.3857	1599.235	1599.235	1599.235	1599.235
INC4_Size2	1193.637	1193.637	1193.637	1193.637	1193.637	303.9023	303.9023	303.9023	303.9023	303.9023	2075.449	2075.449	2075.449	2075.449
INC4_Size3	457.8362	457.8362	457.8362	457.8362	457.8362	186.0664	186.0664	186.0664	186.0664	186.0664	1078.573	1078.573	1078.573	1078.573
INC4_Size4	432.2554	432.2554	432.2554	432.2554	432.2554	168.7322	168.7322	168.7322	168.7322	168.7322	971.9011	971.9011	971.9011	971.9011
INC4_Size5	359.9443	359.9443	359.9443	359.9443	359.9443	150.1071	150.1071	150.1071	150.1071	150.1071	821.4173	821.4173	821.4173	821.4173
INC5_Size1	1153.983	1153.983	1153.983	1153.983	1153.983	547.0649	547.0649	547.0649	547.0649	547.0649	2244.045	2244.045	2244.045	2244.045
INC5_Size2	1541.939	1541.939	1541.939	1541.939	1541.939	877.8607	877.8607	877.8607	877.8607	877.8607	2912.269	2912.269	2912.269	2912.269
INC5_Size3	591.4324	591.4324	591.4324	591.4324	591.4324	537.4766	537.4766	537.4766	537.4766	537.4766	1513.453	1513.453	1513.453	1513.453

Mode Share

This study utilizes the model provided by NCRRP Report 4 and combine it with demographic data projection in the Texas Triangle in 2035. By comparing the different ridership scenarios with the TxDOT report, this paper can provide useful advice depending on future trends.

The model itself distinguishes four different inter-city travel purposes(Business, Visit, Vacation and Other), and under each category, the researcher also computes the percentage of its demographic percentages. For example, under "Business", there are percentages of genders, ages, employment status, education and household income. Since the data from the model is derived from Cascadia and Great Lakes, NHTS 2017 data are used to adjust the proportion of data under different purposes. First, I select the trips that are longer than 50 miles with households located in Texas and Louisiana and reckon them as inter-city trips. Then using the identifiers of the trip purpose, I can easily categorize the trips into the four corresponding categories.

The model provides travel time and costs for four modes of travel (Car, air, bus and rail). All costs and time are set as default 100. In order to change the time and costs, one can input numbers, and 120 would mean 20% more than the original scenario 100.

Because car is the main mode of travel in Texas and Louisiana, car is the second fastest travel mode other than the airplane. Bus has a similar speed but has to make constant stops, which drags down its average speed. There is punishment in the table to reflect its slower travel time and slightly higher costs. In both states, there is not a reliable long-range rail system for people to commute. The Amtrak train is only 30% slower than car, but it is faced with constant stops because of not having right-of-way against freight trains. Passengers would have to stay overnight on an idling train so that it can let cargo trains pass through. The poor reliability of rail and bus are reflected by raising their business and non-business costs.

The first scenario would be business-as-usual, where the rail services have not been improved, and the High-Speed Railways are not built. The demographic and household proportions do not change and they are taken from the average of recent years (2010-2016). The second scenario would be adequate high-speed railway system would be built around the Triangle, but the demographic and household proportion remain the same. The third and fourth scenarios would look at shifts in age pyramids and test how mode shares would shift with more population under 35, more college graduates and less unemployment rate and vice versa. Last, it would test the four different psychological scenarios from the report and change the psychological indicators based on Scenario 2.

TABLE 4-3: OPERATIONS FOR DIFFERENT SCENARIOS

Scenarios	Scenario 1: Business-as-usual	Scenario 2: HSR	Scenario 3: Demographic 1	Scenario 4: Demographic 2
Methods	Input Triangle data; Existing parameters	Decrease Rail travel time and costs; increase rail service frequency	Travel time and cost indices same as HSR; Decrease Under 35 cohort by 5%, 35-44 by 2%; increase 45-54 cohort by 2%, 55-64 cohort by 3%, not college graduate by 5%;	Travel time and cost indices same as HSR; Increase under 35 cohort by 5%, 35-44 cohort by 3%, 45-54 cohort by 2%, non-college graduate by 10%; decrease 55-64 cohort by 9% on average
	Scenario 5: Pessimistic		Scenario 6: Optimistic	
	Travel time and costs indices and demographic same as Scenario 2; Auto-oriented, technology and urbanism attitude same as over 65 cohorts, privacy attitude same as under 35 cohort		Travel time and costs indices and demographic same as Scenario 2; Privacy attitude same as over 65 cohorts, auto-orientation, technology and urbanism same as under 35 cohort	

SUMMARY

In four-step model, the geographical area is small and the residents in that a typical Travel Analysis Zone (TAZ) are around two thousand. Since this is a study involving two states, the geographic area would be comprised of over 20 thousands of small size TAZs. The method enlarges its geographical analysis area and sets county as the appropriate geographical level for analysis. Therefore, the result would not be as accurate as the methods using small geographic zones. The results would lose validity to a certain degree.

As illustrated in Chapter Three, rail transit has its limitation. Without flexibility in stationing, it is expensive to cover all areas, even some of them are not densely populated. Unless the purposes of building train transport are for TOD development or shifting residential and work centers, transit agencies would not locate their stations in remote and isolated areas. The mode choice analysis is built on the presumption that everyone has access to rail transport as well as bus transit. Furthermore, it does not take into account access and egress time, so it seems everyone can get to the stations and destination without transfer or walking. Future studies need to consider more factors in building their mode choice model.

Chapter Five: Understanding Long-Distance Travel Demand and Mode Share

TRIP GENERATION RESULTS

In total, there are about 39 million long-distance trips monthly and 471 million trips annually produced in Texas. In Louisiana, the total trip produced monthly is 5.7 million and 68.5 annually. The drastic difference between the two states is primarily the result of the population difference. Table 5-1 shows top counties with the highest trip production. Counties where anchor cities of the Texas Triangle seat are the top five. Harris County constitutes 6.6 million trips, almost double of the second county. In Louisiana, East Baton Rouge where the city of New Orleans seats, is the county with the highest trip production.

TABLE 5-1: NUMBER OF TRIP PRODUCED MONTHLY BY COUNTY

County FIPs	County	Monthly Trips
48201	Harris	6,590,502
48113	Dallas	3,341,379
48439	Tarrant	2,920,509
48029	Bexar	2,591,660
48453	Travis	1,883,355
48085	Collin	1,691,658
48121	Denton	1,401,547
48157	Fort Bend	1,283,368
48215	Hidalgo	1,147,038
48141	El Paso	1,096,093
48339	Montgomery	968,763
48491	Williamson	906,635
22033	East Baton Rouge	550,928
48039	Brazoria	545,014
48061	Cameron	524,335

MODE SHARE RESULTS

No-Business Case

The no-business scenario outputs are in Table 5-2, after changing the inputs in the demographic section. The inputs are estimated from the NHTS 2017 data. The majority of the mode share for inter-city travel is car, at 80%. The percentage of bus is higher than the share of air because of the model parameters. As the model is adopted from surveys on Cascadia and North-east corridor residents, an inherent preference for bus is revealed here. Business trip makers tend to favor air than bus due to its travel time. The percentage of rail trips is unsurprisingly low at 2.2%, and a large share of them are for vacation purpose.

When tested against long-distance mode share (Table 5-3), NCRRP 4 model output has a similar weighting where the auto has taken the dominant share, and air has percentages from 3% to 14% depending on various purposes. Table 5-2 fits Texas better considering the fact that the inter-city rail system has not been utilized, so generally the region has a lower rail percent than the national average.

TABLE 5-2: MODE SHARE FOR BUSINESS-AS-USUAL SCENARIO (OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	76.7%	80.5%	86.8%	87.0%	*82.8%*
Bus	6.6%	8.1%	4.2%	1.8%	*5.8%*
Rail	1.3%	3.1%	1.3%	3.6%	*2.2%*
Air	15.4%	8.4%	7.7%	7.6%	*9.1%*

TABLE 5-3: MODEL VALIDATION: MODE SHARE OF AGGREGATED NATIONAL MODE SHARE (SOURCE: FEDERAL HIGHWAY ADMINISTRATION, 2015)

Distance-band	Auto	Bus	Rail	Air
Business				
50-150 miles (1-way)	60.3%	0.4%	1.2%	0.2%
150-350 miles (1-way)	16.5%	0.2%	0.6%	1.2%
350+ miles (1-way)	4.7%	0.2%	0.1%	14.4%
Commute				
50-150 miles (1-way)	80.9%	1.1%	9.8%	0.0%
150-350 miles (1-way)	5.3%	0.4%	0.2%	0.0%
350+ miles (1-way)	1.1%	0.0%	0.0%	1.3%
Visiting friends and relatives				
50-150 miles (1-way)	59.6%	0.4%	0.5%	0.1%
150-350 miles (1-way)	22.8%	0.2%	0.3%	0.3%
350+ miles (1-way)	8.5%	0.1%	0.1%	7.2%
Leisure				
50-150 miles (1-way)	63.0%	1.7%	0.5%	0.1%
150-350 miles (1-way)	21.3%	0.8%	0.1%	0.2%
350+ miles (1-way)	6.9%	0.2%	0.1%	5.0%
Personal business				
50-150 miles (1-way)	71.0%	1.1%	0.8%	0.0%
150-350 miles (1-way)	18.2%	0.6%	0.2%	0.2%
350+ miles (1-way)	4.9%	0.2%	0.0%	2.7%

HSR Scenario

The second scenario is computed by changing time and cost indices of the model. In this scenario, it is assumed that high-speed rail has been built and regularly runs among cities. The travel time should be 40% less than driving, and the service frequency would be slightly higher than air or be at the same level. It is expected that the access and egress time would be lower than air because travelers do not have to go through the lengthy boarding and security process.

According to Table 5-4, Texas could expect 16.8% of trips made by rail if there have been HSR system across the region. The aggregate share of rail grows by about 14% and that of auto drop by 10%. The share of bus would remain at the pre-HSR level while that of Air would drop from 9% to little over 5%. Under this assumption, the emerging HSR would attract traveler from all three modes. The air travelers are easy to be converted as almost half of all trips are changed into HSR. The conversion from auto is large in volume but less significant by the rate of change.

Business travelers would appreciate rail than other purpose travelers. The share for business rail exceeds 27%, while rail for other purposes remains at 13% to 17%. There has been a larger proportion of auto-business trips being converted to rail trips than others. From the rate of drop between bus and air, airline could be the biggest loser in these change. Airlines might lose almost half of their business trips, and 2%-4% drops in other purposes, resulting in a steep drop in aggregate rate.

TABLE 5-4: HSR MODE SHARE (OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	59.7%	69.5%	78.0%	78.9%	*72.1%*
Bus	4.2%	8.5%	4.4%	2.7%	*5.7%*
Rail	27.5%	16.9%	13.0%	13.4%	*16.8%*
Air	8.6%	5.1%	4.5%	5.0%	*5.4%*

Demographic Scenario

From the recent data, there are interesting demographic and household trends revealed. The percentages for population under 35, 35 to 44 and 45 to 54 dropped while the proportion of 55 to 64 and 65 and above raised. Also, the unemployment rate has fallen, and more college graduates rate went up. In terms of household income, households with less than $75,000 have dropped, and those with $100,000 or more have had a bigger share.

This scenario is based on the recent demographic change within Texas and Louisiana. According to ACS 5-year data from 2012 to 2017, the proportion of population over 55 has risen, and households in the Triangle have seen increases in income, and average education level and drops in the unemployment rate. This model is built to estimate the mode share changes under these demographic trends. Demographic scenarios are tested against Scenario 2, which is the base scenario for HSR.

The changes in this scenario are minimal. In Table 5-5, the share for rail has increased by 0.7%, and the share for auto is down by 0.5%. Bus trips drop suffer from a minor drop, but air has gained travelers by 0.4%. In NCRRP 4, older population have fewer concerns about privacy, so in the aggregate share, it is not surprised to see the share rail rise. The drop in car trips might occur as people with higher education and higher income in the model are less inclined to drive. Overall, the losses in car and bus trips are picked up the other two modes.

Business trips are more susceptible to the changes, with a 1.6% growth in rail share compared to less than 1% growth out of other purposes. Interestingly, the share of auto drops by 1% in Business purpose and the share for bus goes down by 1.2%. Business air trips only grow by 0.6%. Most of the conversion trips from auto and bus are picked up by rail, and only a small portion of them have turned into air business trips. Rail trips changes for other purposes are less promising than business as the rail have to split the conversion trips half with airlines.

TABLE 5-5: DROP IN YOUNGER POPULATION GROUP AND HIGHER INCOME AND EDUCATED GROUPS(OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	58.7%	68.9%	77.9%	78.7%	*71.6%*
Bus	3.0%	7.9%	3.7%	2.2%	*5.0%*
Rail	29.1%	17.5%	13.7%	13.6%	*17.5%*
Air	9.2%	5.7%	4.7%	5.4%	*5.8%*

The opposite demographic trends are considered in this scenario 4 to explore the fluctuations of mode share. Table 5-6 has seen changes contrary to the previous scene, with more share of car and bus and less share of rail and air. The outputs indicate 0.6% and 0.8% increases in bus and car and 1% and 0.5% decrease in rail and air. Generally, this scenario has bigger fluctuations in rail than its counterpart.

Business and Vacation are more susceptible to changes. Business car and Vacation car grow by 1.1% and 1.6%. The rail drops by 1.5% and 1.4% for business and vacation respectively. Bus tend to get slightly bigger shares of the derived trips. It is unclear which demographic character plays a more significant part in the mode share simulation.

TABLE 5-6: RISE IN THE YOUNGER POPULATION AND DROP IN EDUCATED AND HIGH-INCOME GROUPS (OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	60.8%	71.1%	77.9%	78.4%	*72.7%*
Bus	5.2%	9.4%	5.2%	3.3%	*6.5%*
Rail	26.0%	15.5%	12.5%	13.2%	*15.8%*
Air	8.0%	4.0%	4.5%	5.1%	*4.9%*

Psychological Scenarios

In pessimistic case, it is assumed that people have high values for car-orientation and privacy and are less willing to expose to technology and compact urban development. People of all ages would have the same attitude towards car-orientation, technology and urbanism as over 65 age group and the same attitude towards privacy as under 35 age group.

The output indicates a 1.2 percent drop in rail ridership, and these rail riders are mostly converted to auto. Air and bus have seen minor decreases in ridership as well. Rail shares are more volatile for Visit and Other purposes than Business and Vacation.

TABLE 5-7: PESSIMISTIC CASE FOR RAIL (OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	60.4%	70.6%	79.8%	83.2%	*73.7%*
Bus	4.2%	8.2%	4.0%	1.9%	*5.4%*
Rail	26.6%	16.1%	11.9%	11.0%	*15.6%*
Air	8.8%	5.2%	4.3%	4.0%	*5.3%*

In the optimistic case, people would adopt their attitudes towards car orientation, technology and urbanism from under 35 cohort and the perspectives for privacy would be the same as 65 plus age group.

People with better attitudes towards compact development patterns and new ICT would have the most significant fluctuation among all scenarios. The percentage of rail is up by almost 5.4%, while the percentages of car have decreased by 7.5%. For business trips, rail ridership is 9.4% more than the base case. The rate for car drops by 9.5% and the percentage for air remain unchanged.

TABLE 5-8: OPTIMISTIC CASE FOR RAIL (OUTPUTS FROM NCRRP 4 SPREADSHEET)

Mode	Business	Vacation	Visit	Other	*Total*
Car	50.2%	64.0%	72.1%	63.0%	*64.6%*
Bus	4.4%	10.2%	6.2%	5.5%	*7.3%*
Rail	36.9%	20.5%	16.9%	23.6%	*22.2%*
Air	8.5%	5.3%	4.8%	7.9%	*5.9%*

MONTHLY TRIP RESULTS

This section would use simple multiplication to calculate the total trips under each mode. The mode shares from prior parts have already been established and they multiply trip projection for 2035.

By 2035, Texas is expected to have over 471 million trips generated. Commuting trips are singled out for future analysis. The percentage for commuting is that of business trips. The commute trips in the table have already been calculated as part of the business trip.

No-Business Scenario

TABLE 5-9: MONTHLY TRIPS BY MODE IN 2035 (TEXAS)

	Car	Bus	Rail	Air
Business	8,736,126	753,270	143,210	1,750,950
Vacation	5,259,326	528,458	200,851	548,693
Visit	11,639,673	568,105	177,824	1,031,488
Others	6,917,874	143,643	284,029	604,979
Total	32,552,999	1,993,477	805,914	3,936,110
Commute	3,567,022	307,566	58,474	714,925

TABLE 5-10: MONTHLY TRIPS BY MODE IN 2035 (LOUISIANA)

	Car	Bus	Rail	Air
Business	1,235,054	106,492	20,246	247,537
Vacation	732,923	73,644	27,990	76,464
Visit	1,748,005	85,316	26,705	154,905
Others	1,041,721	21,630	42,770	91,100
Total	4,757,702	287,083	117,711	570,007
Commute	511,146	44,073	8,379	102,447

The car long-distance trips are almost eight times as much as air trips and 16 times as much as that of bus. A limitation of the result is that the rail-business trips cannot be eliminated. In reality, there are few people take rail for long-distance business or commute travel.

Although the cost time-cost for track has been elevated in the model, the result still presents unrealistic numbers of business-rail trips.

HSR Scenario

TABLE 5-11: MONTHLY TRIPS BY MODE IN 2035 (TEXAS)

	Car	Bus	Rail	Air
Business	6,795,968	474,138	3,131,114	982,337
Vacation	4,546,528	555,927	1,103,407	331,466
Visit	10,470,932	592,373	1,749,720	604,065
Others	6,271,764	216,090	1,063,050	399,621
Total	28,085,191	1,838,528	7,047,291	2,317,490
Commute	2,774,841	193,594	1,278,456	401,095

TABLE 5-12: MONTHLY TRIPS BY MODE IN 2035 (LOUISIANA)

	Car	Bus	Rail	Air
Business	960,767	67,030	442,655	138,876
Vacation	633,590	77,472	153,767	46,192
Visit	1,572,487	88,960	262,767	90,716
Others	944,427	32,540	160,078	60,177
Total	4,111,271	266,003	1,019,268	335,961
Commute	397,629	27,742	183,200	57,476

This scenario provides an outlook for Texas, where a higher percentage of travelers taking high-occupant transportation modes. The number of car trips would reduce from 32.6 million to 28.1 billion, and HSR would rise from less than 0.8 million to 7 million.

The shifts from car and bus to rail and air can be beneficial to other on-road vehicles, as a large proportion of vehicle is no longer on the road network. As established earlier, the decrease in car travel would lead to 792 million PMT reductions. (See Table A-4 and A-8) HSR can effectively relieve urban highway from external traffics so that urban highways can better serve inner-city traffics.

Demographic Factors

TABLE 5-13: MONTHLY TRIPS OF DEMOGRAPHIC 1 SCENARIO (TEXAS)

	Car	Bus	Rail	Air
Business	6,681,364	341,891	3,314,583	1,045,718
Vacation	4,504,472	514,402	1,146,499	371,954
Visit	10,457,885	492,810	1,839,123	627,272
Others	6,256,898	175,472	1,085,241	432,916
Total	27,900,619	1,524,575	7,385,445	2,477,860
Commute	2,728,048	139,597	1,353,368	426,974

TABLE 5-14: MONTHLY TRIPS OF DEMOGRAPHIC 1 SCENARIO (LOUISIANA)

	Car	Bus	Rail	Air
Business	944,565	48,334	468,593	147,836
Vacation	627,729	71,685	159,772	51,834
Visit	1,570,528	74,008	276,193	94,201
Others	942,188	26,423	163,420	65,190
Total	4,085,011	220,451	1,067,978	359,062
Commute	390,923	20,004	193,935	61,184

TABLE 5-15: MONTHLY TRIPS OF DEMOGRAPHIC 2 SCENARIO (TEXAS)

	Car	Bus	Rail	Air
Business	6,922,893	590,311	2,954,696	915,655
Vacation	4,647,151	614,808	1,016,207	259,162
Visit	10,449,265	695,699	1,674,765	597,362
Others	6,234,855	265,930	1,046,916	402,824
Total	28,254,164	2,166,748	6,692,584	2,175,003
Commute	2,826,666	241,028	1,206,423	373,868

TABLE 5-16: MONTHLY TRIPS OF DEMOGRAPHIC 2 SCENARIO (LOUISIANA)

	Car	Bus	Rail	Air
Business	978,711	83,454	417,715	129,449
Vacation	647,612	85,678	141,615	36,116
Visit	1,569,233	104,478	251,510	89,710
Others	938,869	40,045	157,649	60,659
Total	4,134,426	313,654	968,489	315,934
Commute	405,055	34,539	172,878	53,575

The population age factor has a positive correlation with rail ridership. As the proportions of population over 55 go up, the rail ridership goes up as well. The NCRRP 4 report also presents the model results that college graduate rate is positively correlated to rail ridership in all purposes. Because the alternations are minor compared to such a big population base, the demographic factors seem not to have significant effects on rail ridership. However, there still are changes in rail ridership changes in these two scenarios. Generally, in Demographic 1 Scenario the rail ridership goes up, and the car trips go down. If the demographic trends spotted in twin-megaregion persist, the rail network would gain favor in the future. It lends advice for policy-makers to understand the general demand for traffic and weigh in less of demographic factors when making decisions.

Psychological Factor

TABLE 5-17: MONTHLY TRIPS FOR PESSIMISTIC SCENARIO (TEXAS)

	Car	Bus	Rail	Air
Business	6,877,202	480,395	3,024,925	1,001,033
Vacation	4,613,604	535,190	1,049,769	338,764
Visit	10,708,104	540,348	1,590,516	578,121
Others	6,611,097	152,641	870,817	315,971
Total	28,810,007	1,708,574	6,536,029	2,233,890
Commute	2,808,010	196,149	1,235,098	408,729

TABLE 5-18: MONTHLY TRIPS FOR PESSIMISTIC SCENARIO (LOUISIANA)

	Car	Bus	Rail	Air
Business	972,252	67,915	427,643	141,519
Vacation	642,937	74,582	146,293	47,209
Visit	1,608,105	81,148	238,858	86,820
Others	995,525	22,985	131,131	47,580
Total	4,218,819	246,630	943,925	323,129
Commute	402,382	28,108	176,987	58,570

TABLE 5-19: MONTHLY TRIPS FOR OPTIMISTIC SCENARIO (TEXAS)

	Car	Bus	Rail	Air
Business	5,720,232	501,426	4,195,947	965,951
Vacation	4,182,472	665,525	1,340,945	348,386
Visit	9,677,807	826,131	2,271,140	642,012
Others	5,010,775	433,399	1,874,663	631,689
Total	24,591,286	2,426,481	9,682,695	2,588,037
Commute	2,335,611	204,736	1,713,235	394,404

TABLE 5-20: MONTHLY TRIPS FOR OPTIMISTIC SCENARIO (LOUISIANA)

	Car	Bus	Rail	Air
Business	839,992	81,677	352,182	92,498
Vacation	496,230	47,461	224,690	57,815
Visit	670,648	65,836	263,755	70,587
Others	1,079,315	103,979	458,709	121,570
Total	3,086,184	298,953	1,299,336	342,470
Commute	847,968	83,347	349,597	90,694

In the Pessimistic Scenario, rail trips would reduce by over 700 thousand monthly, and in the opposite case, rail trips would increase by 2.8 million monthly. People open-minded about technology, urbanism and anti-car would be more likely to take rail for long-distance travel. Although young people have a higher value for privacy according to NCCRP 4, it weighs less when considering the aggregated psychological factors.

Chapter Six: Conclusion

Lacking an accessible and high-quality transit network would put Texas and Louisiana in a disadvantage. For one thing, it causes the ever-worsening congestion in the roadway network. For another, poor connectivity can lead to poor job-house balance, which affects the quality of life for low- and middle-income class.

In Texas and Louisiana, auto has played a dominant role in long-distance transport. This personal vehicle would cause significant congestions on highways. According to TxDOT's I-35 Corridor Study in 2016, as a key link connect the south and north Texas, some links of I-35 see over 200,000 vehicles a day in 2014. Figure 6-3 indicates that all I-35 segments grow over 1.5% in Vehicle Miles of Travel (VMT) and I-35 has a total growth rate at 2.1%. The rural segment of I-35 experience more rapid growth than urban parts as Laredo, Waco and Wichita Falls have growth rates equal to or above 2.5%. Figure 6-2 shows that by 2040, most parts of I-35 would have the level of service (LOS) at D or worse. Non-urban parts would have LOS at D so that they result in unstable flows that impact drivers. As it reaches urban peripheral area and urban core, the highway sees delays by one-third of average speed.

Another major highway connecting Texas and Louisiana would stretch its capacity as well. Figure 6-1 indicates some congestions on I-10 around El Paso, San Antonio, and Houston. The I-10 segment connecting Houston and Louisiana also have LOS at C, and if no improvement were to be done on the link, it would have delays in the future. In East Baton Rouge, Louisiana the AADT on I-10 also exceeded 100 thousand in 2017.

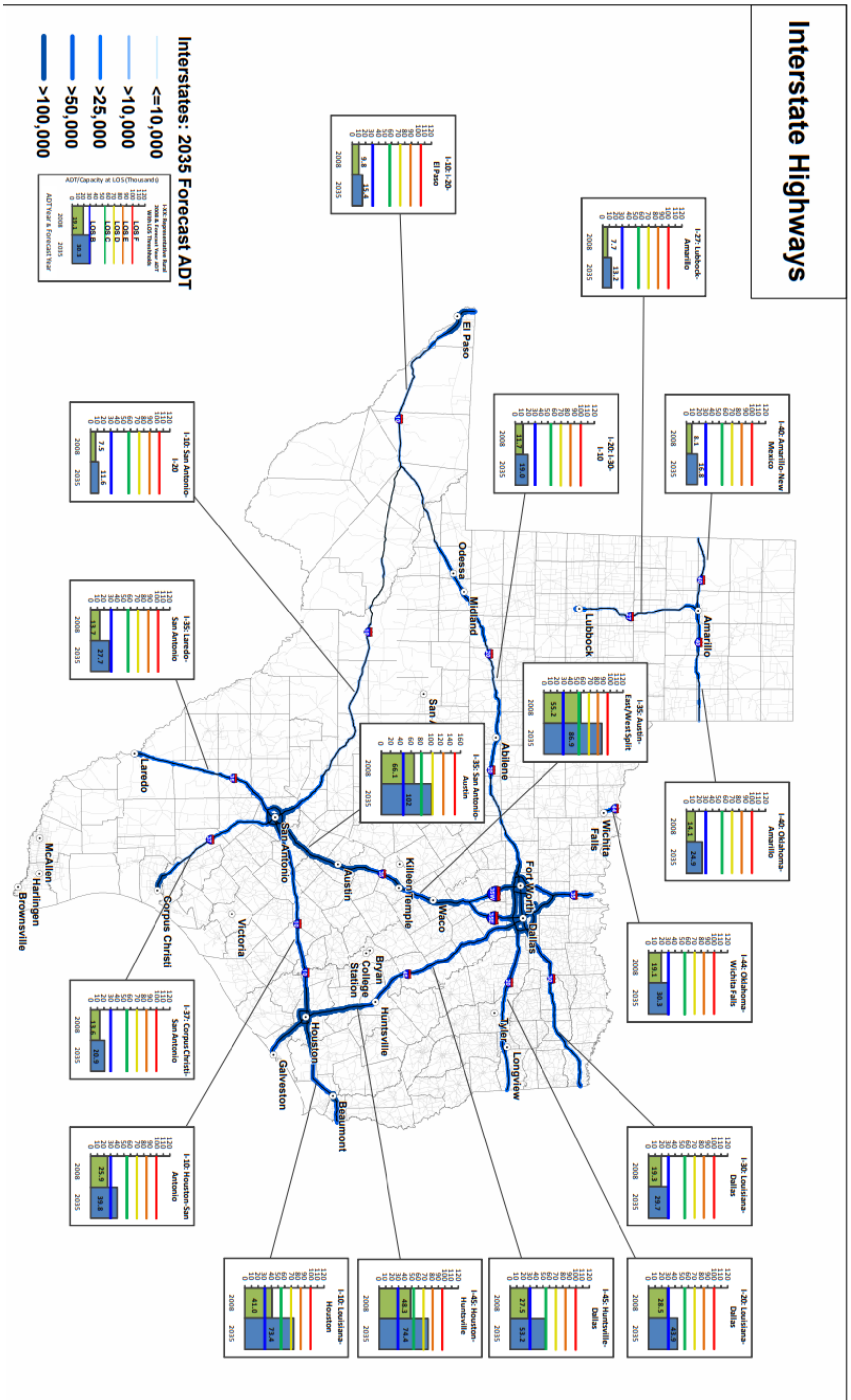

Figure 6-1: Interstate Highways AADT Forecast (Source: TxDOT, n.d.)

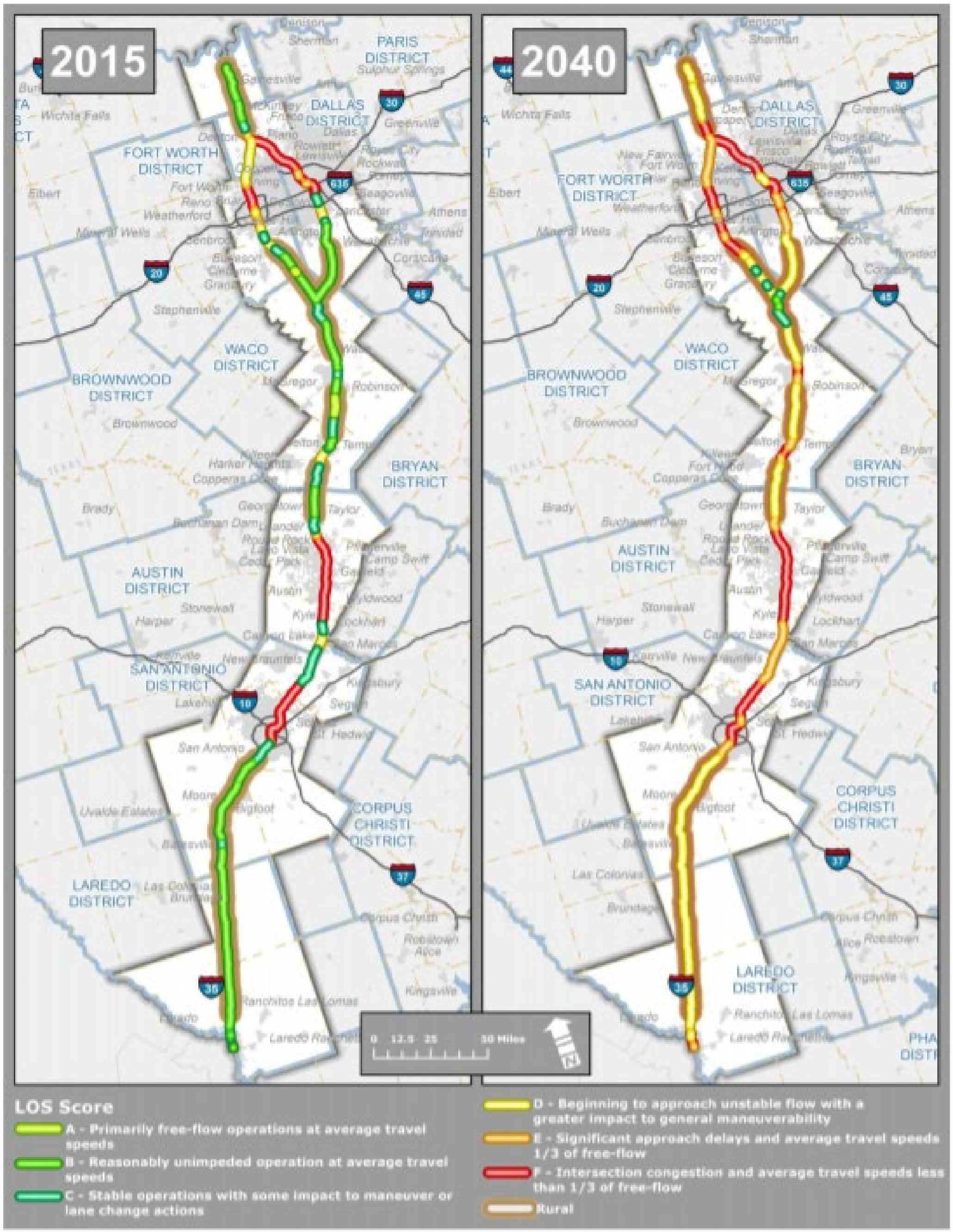

Figure 6-2: I-35 Level of Service 2015 and 2040 (Source: TxDOT, 2016)

Estimated 2015 and 2040 Vehicle Miles of Travel and Average Annual Growth Rates by District			
District	2015 VMT	2040 VMT	AAGR
Wichita Falls	910,505	1,807,435	2.8%
Dallas	13,830,016	22,210,901	1.9%
Ft. Worth	5,370,282	8,245,934	1.7%
Waco	7,315,924	13,426,150	2.5%
Austin	10,601,043	15,702,749	1.6%
San Antonio	9,663,034	15,142,537	1.8%
Laredo	3,164,799	6,215,068	2.7%
Total	50,855,603	82,750,774	2.1%

Figure 6-3: I-35 Vehicle Miles of Travel from TxDOT (Source: TxDOT, 2016)

Although the buzz of building HSR in Texas Triangle has faded over the decade, it remains a solution to the traffic problem in the region. The adopted mode share forecast model also shows a huge conversion to rail transport from car and airplane. A 16% of rail trips among all modes is a persuasive number for advocating HSR in the region. However, the number is only hypothetical, and it assumes that all people have access to rail system. In reality, the service population can effectively serve a large percentage of urban population but a small portion of suburban and rural population. The mode share percentages and the trip number taking train should be adjusted to reflect Texas and Louisiana's situation.

The latter of the chapter will not discuss the political and financial barriers of building HSR or commuter rail in Texas and Louisiana as it is not the center of the research. It would provide suggestions on how rail system can become acceptable to residents based on the analysis so far.

SUGGESTIONS

Psychological factors can make a big difference. In NCRRP 4, it stresses that the attitude for urbanization, ICT, and privacy have high weights in determining the mode share for the railway. Demographic data in Texas and Louisiana both show an upward trend in the percentage of the population over 45. For the elder population, they take more travel trips. According to the AARP Travel Survey, the Boomer population takes 4 to 5 trips a year on average, and half of those trips are domestic. (AARP, 2019) HSR in the future could offer faster time to destination and modern amenities, and it can change the proportion of air and car mode in long-distance travel and visit trips.

For median distance train lines, line with frequent stops perform better than those with few stations. The case of Sounder Train has shown that line with frequent stop and cutting through densely populated areas has higher ridership. The north line of Sounder goes along the shore of Puget Sound and misses communities in the north of Seattle. On the contrary, the south line connects cities in the south. It not only serves suburban residents traveling to downtown Seattle but also attracts people to travel between intermediate stops.

Multimodal connection can be the final push for people to take rail. As a legacy track, MARC train goes through densely populated communities, its stations also have good connections to bus lines. Silver Spring station is located just outside Washington DC. The station has a direct connection to buses and walking and biking trails. The station has over 30 platforms for transferring passengers to take buses and vans. The station does not have park and ride lots, but passengers can park in nearby parking lots, which will cost $5 to $9 daily. To encourage shared ride, the station has a kiss and ride lane on the third floor. In Texas, most cities do not have adequate buses for day-to-day activity. New bus lines can base their terminal in the station area to provide a complete trip for commuters and travelers.

Although the market mechanism is the determining factor, TDM measures can have push and pull effects. TDM measures in Washington states have proven effective, and Texas can learn from its case. A region must have an effective transit network to start with. In other words, only when the cost of taking transit is cheaper than driving alone, would people choose to take transit. Currently, the city of Austin has dozens of transit lines for long-distance trip takers. If you first landed in Austin, you can either choose to take the only bus line, rent a car, or reserve a vanpool. Renting a car is convenient, and you can choose to go anywhere you like, so car is the obvious best choice than transit. Also, the frequency of the bus is low, and many areas of the city do not have access to buses, so they all serve as deterring factors in pushing regional TDM in the metro area. After transit agencies succeed in providing comprehensive transit solutions for regional travel, TDM measures would do the push and pull work. Without TDM, taking the rail from Round Rock to downtown Austin would cost $3.5 one-way, and a round trip would cost $7. It is already costly enough, and thus the station nowhere close to your destination. Meanwhile, driving yourself would probably cost the same amount of time and costs you a cheaper value in fuel. In this case, if employers offer public transit stipend, employees are more likely to use public transit. If downtown parking spaces are scarce and expensive, travelers would think twice about renting a car. They would use a combination of public transit and ride-sharing software.

Transit authorities should increase capacity and plan for the potential demand. The planning for rail transportation has to consider future population growth. Texas has increased in its population by 3.5 million from 2010 to 2018, and it will continue to grow at a faster rate in the future. Although the population in Louisiana is flat-lining, East Louisiana is still booming. It is imperative to plan for multiple tracts and more cars to accommodate future needs. Maintaining and operating a train system is costly. The smart way to combat the increasing costs is to increase ridership so that the cost per capita would go down. Another approach to this issue is to make sure the network capacity is the same as the saturation level of rail transit. The transit agency will design their system capable of handling all possible travellers are taking rail.

Changing the travel mode of people is hard, and it would last generations for people to abandon their original habit of driving. Without the presence of passenger rails in Texas and Louisiana, it poses more difficulties on the local and regional authorities to promote a mode that people are not familiar with and not excited about. This report merely provides a preliminary look into the future in terms of travel demand and mode split. A full four-step model with Texas Statewide Analysis Model (SAM) is strongly encouraged to identify top destinations, and network flows across Texas and even Louisiana.

Appendices

APPENDIX A

TABLE A-1: TRAVEL DESTINATIONS BY STATE (TEXAS)

Destination State	State	Count	Destination	State	Count
Texas	TX	2208	Pennsylvania	PA	5
Foreign	ZZ	112	Michigan	MI	5
Louisiana	LA	84	Washington	WA	5
Oklahoma	OK	48	Kansas	KS	5
New Mexico	NM	33	Massachusetts	MA	4
California	CA	26	Minnesota	MN	4
Florida	FL	19	Indiana	IN	4
Colorado	CO	19	Virginia	VA	4
Arkansas	AR	17	South	SC	4
Nevada	NV	11	Connecticut	CT	3
Georgia	GA	9	Maryland	MD	3
Missouri	MO	9	Kentucky	KY	3
North Carolina	NC	9	Tennessee	TN	3
Illinois	IL	9	Oregon	OR	3
Arizona	AZ	9	Hawaii	HI	2
New York	NY	5	North Dakota	ND	2
Iowa	IA	7	Mississippi	MS	2

Table A-1 Continued

Ohio	OH	7	New Jersey	NJ	1
Washington, DC	DC	6	Vermont	VT	1
Alabama	AL	6	Utah	UT	1
			Wyoming	WY	1

TABLE A-2: TRAVEL DESTINATION BY MSA/PMSA (TEXAS)[4]

Destination MSA Name	Fort Worth	Houston	Suppressed	Grand Total
Atlanta, GA	4	3	1	9
Austin-San Marcos, TX			2	138
Bergen-Passaic, NJ		1		1
Birmingham, AL	1			1
Boston MA-NH		1		4
Charlotte-Gastonia-Rock Hill, NC-SC		4		4
Chicago, IL	1	2	5	9
Cincinnati, OH-KY-IN	1			4
Cleveland-Lorain-Elyria, OH				1
Columbia, SC				1
Columbus, OH			1	1
Dallas, TX		10	8	325

[4] Supressed, the destination is in an MSA less than 1 million

Table A-2 Continued

Denver, CO	1	2		4
Des Moines, LA			1	1
Detroit, MI			1	1
Fort Worth-Arlington, TX	2	1	2	85
Fresno, CA	1			1
Grand Rapids-Muskegon-Holland, MI	1		1	2
Greensboro-Winston-Salem-High Point, NC	1			1
Harrisburg-Lebanon-Carlisle, PA		1		1
Houston, TX	5		6	333
Indianapolis, IN	1			1
Kansas City, MO-KS			1	1
Knoxville, TN				1
Las Vegas, NY-AZ	2	2	6	11
Lexington, KY				2
Little Rock-North Little Rock, AR				7
Los Angeles-Long Beach, CA	1	3	1	8
Memphis, KY-IN				1
Minneapolis- St Paul, MN-WI		1	2	3
Mobile, AL				5
Nassau-Suffolk, NY			1	1

Table A-2 Continued

New Orleans, LA	1	3	7	16
New York, NY	3		3	6
Oklahoma City, OK		2		21
Orange County, CA		1		1
Orlando, FL		4		4
Philadelphia, PA-NJ			1	1
Phoenix-Mesa, AZ	1		1	7
Pittsburgh, PA			1	1
Portland-Vancouver, OR-WA			3	3
Raleigh-Durham-Chapel Hill, NC	1			1
Riverside-San Bernardino, CA				4
St Louis, MO-IL		1		1
Salt Lake City-Ogden, UT	1			1
San Antonio, TX	6		4	157
San Diego, CA	1			3
San Francisco, CA	2		1	5
San Jose, CA		2	1	3
Seattle-Bellevue-Everett, WA	3		1	5
Springfield, MO				1
Tampa- St Petersburg-Clearwater, FL	5			5

Table A-2 Continued

Tucson, AZ				1
Washington, DC	6	3		9
West Palm Beach-Boca Raton, FL			1	1
Not in an MSA	16	22	32	866
Suppressed	12	12	22	630
	80	**81**	**117**	**2721**

TABLE A-3: MODE SHARE OF LONG DISTANCE TRIP (TEXAS)

Travel Mode	Count	Percentage
Car	1071	39.36%
Van	284	10.44%
SUV	412	15.14%
Pickup Truck	539	19.81%
Other Truck	101	3.71%
RV	7	0.26%
Motorcycle	6	0.22%
Commercial Airplane	220	8.09%
Private Airplane	22	0.81%
School Bus	19	0.70%
Tour Bus	24	0.88%

Table A-3 Continued

City to city bus	11	0.40%
Ship/Cruise	3	0.11%
Other	1	0.04%

TABLE A-4: AVERAGE PERSON MILES TRAVELLED (PMT) BY DIFFERENT MODE (TEXAS)

Modes	Average Person Miles Travelled
Car	176.39
Air	1257.68
Bus	274.64
Ship	958.19
Other	73.60

TABLE A-5: DESTINATION BY STATE (LOUISIANA)

States by Destination	Total
AK	1
AL	28
AR	8
AZ	2
CA	4
CO	7
FL	15

Table A-5 Continued

GA	7
IA	1
LA	374
MO	3
MS	68
NC	4
NJ	2
NM	1
OK	2
TN	3
TX	86
UT	1
VA	2
ZZ	2
Grand Total	**621**

TABLE A-6: DESTINATION MSA (LOUISIANA)

Destination MSAs	Grand Total
Atlanta, GA	6
Birmingham, AL	5
Dallas, TX	19
Denver, CO	2
Des Moines, IA	1
Houston, TX	19
Jacksonville, FL	2

Table A-6 Continued

Little Rock- North Little Rock, AR	4
Los Angeles, CA	1
Memphis, TN	2
Mobile, AL	19
New Orleans, LA	79
Newark, NJ	2
Oklahoma City, OK	2
Orlando, FL	1
Phoenix, AZ	2
Richmond-Petersburgh, VA	2
Sacramento, CA	2
St. Louis, MO	2
Salt Lake City, UT	1
San Antonio, TX	10
San Diego, CA	1
Not an MSA	155
	282
	621

TABLE A-7: MODE SHARE PERCENTAGE (LOUISIANA)

Travel Mode	Count	Percentage
Car	252	40.58%
Van	98	15.78%
SUV	65	10.47%
Pickup Truck	117	18.84%
Other Truck	22	3.54%
RV	4	0.64%
Commercial Airplane	43	6.92%
Private Airplane	2	0.32%
School Bus	4	0.64%
Tour Bus	9	1.45%
City to city bus	2	0.32%
Other	1	0.01%

TABLE A-8: PMT BY MODE (LOUISIANA)

Mode	PMT
Car	161.29
Air	1198.37
Bus	229.72
Other	277.9

APPENDIX B

TABLE B-9: MAJOR CORRIDORS IDENTIFIED FROM COMMUTE FLOWS

A County	B County	AB	BA
Collin	Tarrant	1,690,782	1,931,924
Harris	Jefferson	938,305	192,659
Dallas	Harris	736,876	697,469
Bexar	Travis	511,702	575,333
Harris	Travis	442,975	362,716
Fort Bend	Montgomery	413,246	253,859
Dallas	Travis	396,190	313,434
Bexar	Harris	367,802	396,082
Denton	Harris	366,758	55,087
Bell	Travis	355,703	299,353
Harris	Walker	316,411	78,814
Hidalgo	Nueces	290,667	9,950
Harris	Tarrant	284,087	260,891

Table B-1 Continued

Bexar	Frio	275,787	12,059
El Paso	Midland	275,074	N/A
Bexar	Hays	268,886	273,457
Dallas	Grayson	224,891	156,627
Bexar	Dallas	223,646	311,976
Brazos	Harris	222,450	310,492
Harris	Washington	219,439	42,132
Harris	Midland	193,944	15,593
Harris	Nueces	189,391	62,774
Guadalupe	Travis	174,127	59,983
Bexar	Nueces	160,514	77,066
Harris	Hays	155,701	44,184
East Baton Rouge	Jefferson	155,219	245,303

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